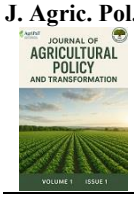
AgriPaT
Journal of Agricultural Policy & Transformation

TAEF
The AgEcon Frontiers

JOURNAL OF AGRICULTURAL POLICY AND TRANSFORMATION

VOLUME 1 ISSUE 2

J. Agric. Pol. & Transf. Vol. 1(2)



Journal of Agricultural Policy and Transformation (AgriPaT)

Journal homepage: http://www.ageconfrontiers.com/agripat

Climate Change, Agricultural Performance, and Resilience in Bangladesh: An Empirical Analysis

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ARTICLE INFO

Keywords:
Agriculture
Climate Change
Sustainable Farming
Food Security
Mitigation

Received:
12 October 2025
Received in revised form:
10 December 2025
Accepted:
17 December 2025
Available online:
20 December 2025

ABSTRACT

As the impacts of climate change grow more severe, Bangladesh is pioneering green agriculture to secure its agricultural future. This approach embraces sustainable farming practices, enabling farmers to adapt to shifting environmental conditions while safeguarding food security and protecting natural resources. Climate change is significantly impacting Bangladesh's agriculture sector, leading to reduced crop yields, increased salinity, and shifts in rainfall patterns. These changes threaten food security and livelihoods, particularly for coastal communities. However, Bangladesh is also pioneering green agriculture and adaptation strategies to mitigate these effects. Climate change poses significant challenges to Bangladesh's agriculture sector, but the country is actively working towards adaptation and mitigation strategies to build resilience and ensure food security. By promoting green agriculture, implementing water management techniques, and supporting farmers with the necessary resources and knowledge, Bangladesh can strive to overcome the challenges of climate change and build a more sustainable agricultural future. In this paper the author analysis the impact of environmental change on agriculture of Bangladesh. The study used trend analysis, Chi square test, and regression analysis for data analysis purposes.

1. Introduction

As climate change intensifies globally, low-lying delta countries such as Bangladesh face rising temperatures, erratic rainfall, sea-level rise, coastal salinity intrusion and more frequent extreme events, all of which already reduce yields and undermine food systems. (IPCC, 2022; Alotaibi, 2023; Sheikh, 2025). Bangladesh's agro-based economy remains central to food security, employment and GDP, yet is increasingly exposed to these climate shocks, with evidence of declining crop productivity and heightened production risk, particularly for smallholder farmers (Chowhan et al., 2023; Ahmed et al., 2024; Sheikh, 2025). Recent studies highlight how salinity in coastal zones, changing rainfall patterns and recurrent floods are reshaping cropping systems and threatening rural livelihoods (Bhuyan & Raju, 2018; Hasan et al., 2018; Rahman et al., 2022; Bhuyan et al., 2024). In response, Bangladesh has begun to promote a range of green and climate-smart agricultural (CSA) practices, including improved water management, crop diversification, stress-tolerant varieties and resilient technologies, supported by national programs and investment projects (Hasan et al., 2018; Chapagain et al., 2023; Nandi et al., 2024; World Bank, 2024). Building on this context, the present study analyses the impacts of key environmental changes on Bangladeshi agriculture, using trend analysis, chi-square tests and regression models to examine the links between climate stressors and agricultural performance and to draw implications for future resilience strategies (Rahman et al., 2022; Sheikh, 2025).

The general objectives of this research are threefold: to identify the key environmental factors affecting agriculture in Bangladesh, to evaluate long-term agricultural trends within the country, and to assess the specific impact of climate change on agricultural productivity and sustainability (Habib et al., 2025; Uddin and Hoque, 2025). These are refined into specific objectives: first, to pinpoint the multifaceted factors affecting the agriculture of Bangladesh; second, to evaluate the historical and contemporary agricultural trends of the nation; and third, to

assess the tangible impact of environmental change on the agricultural sector (Rahman and Rahman, 2019; Saleem et al., 2025).

A growing body of literature firmly establishes that Bangladesh's agriculture, while vital, is significantly compromised by climate change, necessitating the immediate implementation of climate-resilient strategies (Chowdhury et al., 2022; Kibria et al., 2022; Majumder et al., 2024). The country's high vulnerability to climate-induced disasters such as floods, cyclones, and sea-level rise poses a direct threat to national food security and rural livelihoods (Rahman et al.,2024; Akter and Nasher, 2025; Tasnim et al., 2025). The impacts are multifaceted and severe. The increased frequency and intensity of extreme weather events including floods, droughts, cyclones, and heatwaves routinely disrupt agricultural production cycles and damage critical infrastructure (Rahman and Rahman 2019; Habib et al., 2025;). Concurrently, sea-level rise drives salinity intrusion into coastal soil and water sources, rendering vast tracts of previously arable land less productive (Miah et al., 2020; Ashrafuzzaman et al., 2022; Feist et al., 2025). Furthermore, erratic rainfall patterns, oscillating between prolonged dry spells and excessive downpours, create unreliable growing conditions that negatively affect crop growth and productivity (Uddin and Hoque, 2025; Saleem et al., 2025). These changing climatic conditions also foster increased pest and disease outbreaks, creating new challenges for crop protection (Pathak et al., 2018; Majumder et al., 2024). Cumulatively, these factors project a worrying trend of reduced agricultural productivity and overall output for Bangladesh (Chowdhury et al., 2022; Habib et al., 2025).

In recognition of these threats, the literature documents a range of climate-resilience measures being deployed in Bangladesh's agricultural sector. A cornerstone of this effort is the development and dissemination of climate-resilient crop varieties, such as those bred for flood tolerance, drought resistance, and salt tolerance (Debsharma et al., 2024). Parallel to this is the promotion of climate-smart agricultural practices, including techniques like alternative wetting and drying (AWD) irrigation, deep placement of urea fertilizer, and the incorporation of crop residues to enhance soil health and water use efficiency (Ruba et al., 2024). Strengthening disaster preparedness through early warning systems and robust response mechanisms is also deemed essential, particularly in highly exposed haor regions where recent flash floods have highlighted farmers' vulnerability and adaptation needs (Ferdushi et al., 2019). Other critical strategies include diversifying crops and farming systems to spread risk, promoting sustainable water management to address scarcity, and enhancing agricultural research and development for long-term adaptation (Debsharma et al., 2024; Ruba et al., 2024). Empowering farmers through training and extension services, integrating valuable indigenous knowledge, and establishing supportive policy and institutional frameworks are all identified as vital components of a comprehensive resilience strategy (Ferdushi et al., 2019; Ruba et al., 2024).

Beyond the direct impacts of climate change, the sector contends with a host of other persistent challenges. Land degradation, driven by the loss of arable land to urbanization and industrialization, soil degradation from the overuse of agro-chemicals, and riverbank erosion, continues to shrink and impoverish the country's productive land base (Khan & Shoumik, 2022; Islam & Eusuf, 2025). In coastal zones, salinity intrusion and changes in ecosystem services further undermine agricultural potential and human well-being (Hossain et al., 2016). A rapidly growing population exerts immense pressure on food production systems, demanding increased output from a limited resource base, while recurrent riverbank erosion displaces farming households and disrupts production systems. These environmental stresses interact with climate variability to create increasingly fragile production conditions and raise the risk of crop failure (Habib et al., 2025).

Despite these formidable challenges, agriculture remains a cornerstone of the Bangladeshi economy, contributing significantly to GDP and employing a large portion of the workforce (Pervez et al., 2024). While its relative share of GDP is gradually decreasing with the growth of other sectors, its absolute importance for food security, poverty reduction, and rural development is undiminished (Habib et al., 2025). At the same time, most producers are smallholders who face persistent constraints in access to credit, technology, and markets, which limit their capacity to respond to these changes (Quddus & Kropp, 2020; Rayhan et al., 2023). Deficiencies in agricultural marketing and infrastructure, such as poor storage facilities, inadequate transportation, and post-harvest losses, further reduce profitability and raise income risk (Bhuya & Raju, 2018; Quddus & Kropp, 2020). The sector's future trajectory therefore hinges on its ability to navigate the dual demands of enhancing productivity to feed a growing nation while simultaneously adapting to and mitigating the effects of a changing climate (Pervez et al., 2024; Habib et al., 2025). This research contributes to this imperative by quantitatively examining the relationships between environmental stressors and agricultural outcomes, thereby providing evidence-based insights that can guide policy and practice in

building a climate-resilient agricultural future for Bangladesh.

The methodological approach of this study relies entirely on secondary data**.** District- and national-level information on cropped area and production for the six main crops was taken from the published statistics and reports of the relevant Bangladeshi agencies (e.g., agricultural sample survey reports and statistical yearbooks). These institutions already apply their own established sampling and estimation procedures to produce official area estimates. In the present study, we do not conduct any primary data collection; rather, we analyze only the aggregated figures reported in these official sources to examine long-term trends and relationships. For each crop, the area within sampled clusters is calculated, and the compiled data from cluster reports are analyzed at the Bangladesh Bureau of Statistics (BBS) headquarters.

The total acreage for a crop at the district level is subsequently derived using the method of ratio estimation, providing a reliable foundation for tracking agricultural trends and measuring impacts. Although a large body of work has examined the impacts of climate change on Bangladeshi agriculture, most existing studies are either local case studies focusing on a single hazard or crop, or they rely on simulation models without systematically linking observed environmental changes to long-run agricultural outcomes. Very few studies analyze national time-series data that combine multiple environmental stressors with area and production statistics for the main crops, and even fewer employ a consistent empirical framework to compare how different factors shape agricultural trends over several decades. Moreover, most of the literature discusses climate-smart or resilience strategies in qualitative terms, without grounding these discussions in an empirical assessment of how climatic and other environmental pressures are already reflected in aggregate agricultural performance.

This study fills these gaps in three ways. First, it compiles and harmonizes long-run, nationally representative secondary data on cropped area, production and yield for Bangladesh's six major crops together with key environmental indicators. Second, it applies to a transparent empirical strategy that combines trend analysis, chi-square tests and regression models to quantify the association between environmental stressors and agricultural outcomes at the national level. Third, by linking these empirical results to the ongoing policy discourse on climate-smart agriculture, the study provides evidence-based insights that can inform the prioritization of adaptation measures and investment in resilience. In doing so, the paper contributes a country-level, data-driven perspective to the literature on climate change and agricultural sustainability in Bangladesh.

2. Materials and Methods

This study adopts a purely quantitative approach, relying exclusively on secondary numerical data and applying statistical techniques such as trend analysis, chi-square tests and regression models to examine the relationships between environmental stressors and agricultural outcomes.

Data Sources

The analysis primarily relies on secondary data obtained from reputable national sources. Key datasets include comprehensive agricultural statistics, damage reports, and production estimates published by the Bangladesh Bureau of Statistics (BBS). Furthermore, data from the Seed Wing of the Ministry of Agriculture and the Bangladesh Meteorological Department were utilized. These official sources provide a reliable and longitudinal basis for the study. The study adopts a purely quantitative approach, relying exclusively on these secondary numerical datasets and applying statistical techniques such as trend analysis, chi-square tests, and regression models.

Analytical Techniques

The data were subjected to a series of statistical analyses to address the research objectives.

Trend Analysis

Long-term changes in crop yields, climatic variables, and area allocations were examined using trend analysis. This technique was applied to data spanning multiple years (e.g., 2005-06 to 2020-21 for seed supply, and 2019-20 to 2022-23 for land use and crop production) to identify patterns of growth, decline, or stability in key agricultural indicators.

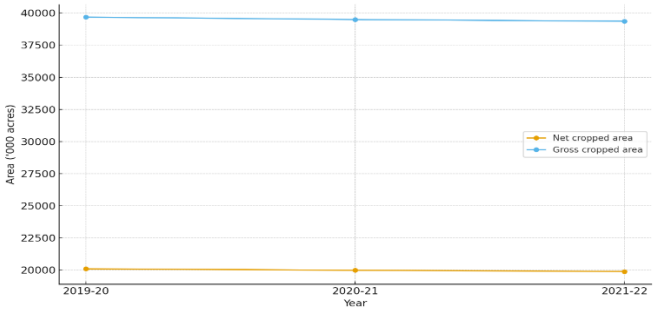


Figure 1. *Trends in net and gross cropped area in Bangladesh, 2019–20 to 2021–22.*

The line graph in figure 1 shows a mild but consistent decline in both net and gross cropped areas over the three-year period. Net cropped area fell from 20,081 to 19,875 thousand acres, while gross cropped area declined from 39,678 to 39,358 thousand acres, indicating gradual contraction of cultivated land and overall cropping intensity.

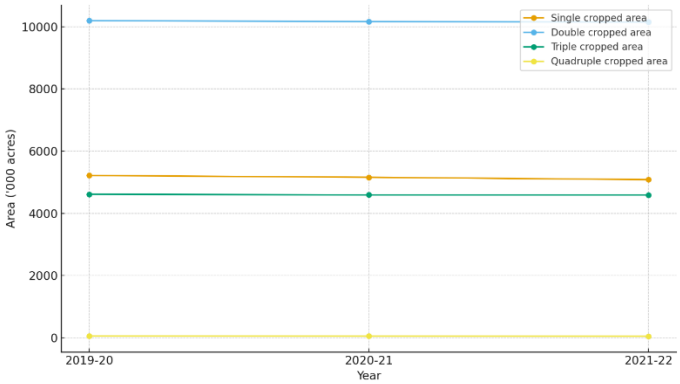


Figure 2. *Changes in cropping pattern (single to quadruple cropped area), 2019–20 to 2021–22.*

All categories of cropped areas declined slightly. Single-cropped land decreased from 5,216 to 5,084 thousand acres, double-cropped from 10,194 to 10,149, triple-cropped from 4,613 to 4,592, and quadruple-cropped from 56 to 50 thousand acres. This points to a modest reduction in multiple cropping and overall cropping frequency.

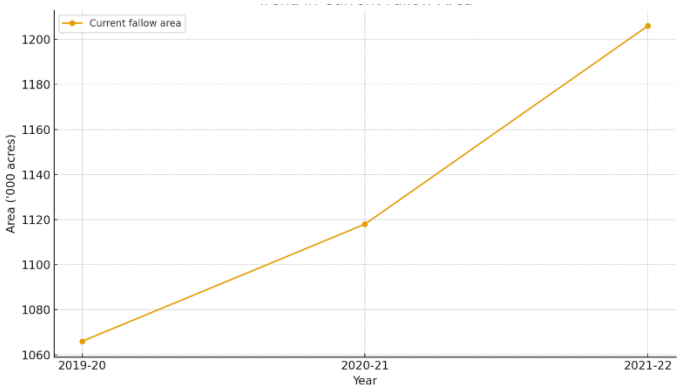


Figure 3. *Trend in current fallow area, 2019–20 to 2021–22.*

Current fallow land increased steadily from 1,066 to 1,206 thousand acres, suggesting that more land is being left uncultivated, possibly due to soil, water, labor, or profitability constraints.

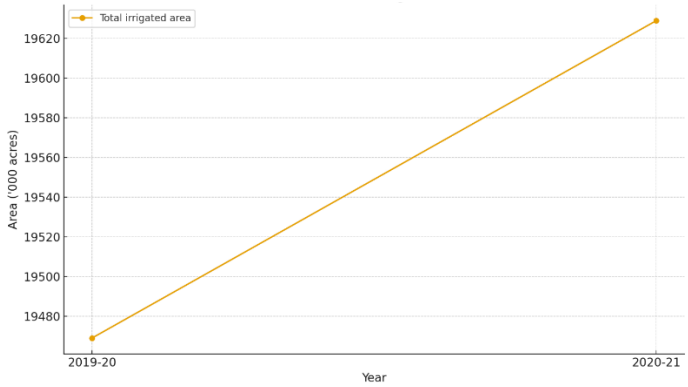


Figure 4. *Trend in total irrigated area, 2019–20 to 2020–21.*

Total irrigated area rose slightly from 19,469 to 19,629 thousand acres, indicating a modest expansion of irrigation coverage, although data for 2021–22 are not available.

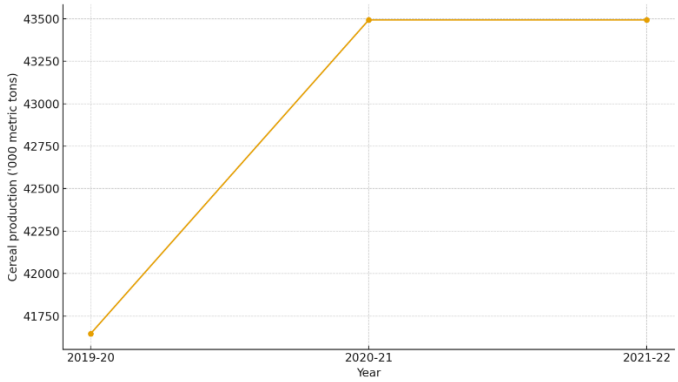


Figure 5. *Trend in total cereal production in Bangladesh, 2019–20 to 2021–22.*

Total cereal production increased from 41,647 to 43,493 thousand metric tons between 2019–20 and 2020–21 and then remained stable in 2021–22. This suggests that yield improvements or efficiency gains are compensated for by the decline in cropped areas.

Regression Analysis

Linear regression analysis was employed to quantify the relationship between continuous variables. Specifically, it was used to model the relationship between time and the demand and supply of seeds, providing a predictive understanding of future gaps. The model takes the form of $Y = a + bX$, where Y is the dependent variable (e.g., demand), and X is the independent variable (time).

Descriptive and Comparative Analysis

A significant portion of the analysis involves descriptive presentation and comparative examination of data. This includes comparing area, yield, and production figures for

major crops (Aus, Aman, Boro, oilseeds, spices, narcotics) across different years and districts. In the Bangladeshi context, *Aus*, *Aman* and *Boro* are the three major seasonal rice ecosystems**,** defined by their sowing and harvesting periods rather than by specific varieties. Aus rice is typically sown in the pre-monsoon (March–April) and harvested in June–July; Aman rice is transplanted during the monsoon (July–August) and harvested in November–December; Boro rice is irrigated dry-season rice, transplanted in December–January and harvested in April–May. In contrast, oilseeds, spices and narcotics in this study refer to crop groups**:** oilseeds (e.g., mustard, sesame), spices (e.g., chilli, onion, turmeric) and narcotic crops (e.g., tobacco). Damage data from specific natural disasters (e.g., Cyclone Bulbul, 2022 floods) were also analyzed to assess localized impacts on different crop types.

Scope and Data Treatment

The study covers multiple agricultural seasons and a wide range of crops central to food security in Bangladesh. All data, including tables on crop estimates and disaster damage, are presented and analyzed in their original form without alteration. References to specific data source, Chowdhury et al. (2022), are retained as provided in the original text.

3. Results and Discussion

Results

This section presents the findings from the comprehensive data analysis, followed by an integrated discussion that interprets these results in the context of Bangladesh's climate resilience challenges and strategies.

Statistical Associations between Crop Varieties and Outcomes

The Chi-square tests revealed significant associations between crop varieties and agricultural performance metrics, underscoring the dynamic nature of agricultural decision-making in response to environmental and economic pressures.

Aus Crop Analysis

For the Aus season, a highly significant association was found between the variety of seeds (Local vs. HYV) and area allocation between 2021-22 and 2022-23 ($\chi^2 = 775.26$, df=1, $p < 0.05$). This is reflected in the data, which shows an 8.44% overall decrease in the area under Aus cultivation, with Local varieties declining more sharply (-15.53%) than HYVs (-7.76%) (Table 1: Estimates of Total Area by Type of Aus Crops). This suggests farmers are abandoning Aus cultivation, particularly local varieties, potentially due to lower profitability or heightened climate vulnerability early in the season.

A significant relationship was also confirmed between crop type and yield per area ($\chi^2 = 8.78$, df=1, $p < 0.05$). As shown in the yield table, HYV Aus consistently yielded significantly more (2.846 MT/Hectare in 2022-23) than local varieties (1.438 MT/Hectare). Despite this yield advantage for HYVs, which increased by 5.60% overall, total Aus production fell by 3.32% due to the substantial reduction in cultivated area. The association between variety and production distribution between the two years was also significant ($\chi^2 = 100.17$, df=1, $p < 0.05$), confirming that the decline was not uniform across varieties.

Table 1: Estimates of Total Area by Type of Aus Crops:

Variety	2021-22		2022-23		Percentage (%) changes over previous year
	Area (In acres)	Area (In Hectors)	Area (In acres)	Area (In Hectors)	
Local	248505	100569	209921	84954	(-)15.53%
HYV	2615582	1058511	2412484	976319	(-)7.76%
Total (Local+ HYV)	2864087	1159080	2622404	1061273	(-)8.44%

Aman Crop Analysis

The analysis of the Aman season revealed a more complex picture. While the total area under Aman cultivation remained nearly stable (+0.082%), the distribution among different cultivation methods changed significantly. The Chi-square test confirmed a significant association between the type of Aman crop and the distribution of area between years. The data shows a marked shift: the area under Broadcast (traditional) methods and Local Transplant (L.T.) decreased by 11.77% and 5.05%, respectively, while the area under HYV Aman increased by 1.48% (Table 2:

Estimates of Total Area by Type of Aman Crops). This indicates a clear transition towards more productive and potentially more resilient hybrid varieties, a key adaptation strategy.

Table 2: Estimates of Total Area by Type of Aman Crops

Variety	2021-22		2022-23		Percentage (%) changes over previous year
	Area (in acres)	Area (in Hectors)	Area (in acres)	Area (in Hectors)	
Broadcast	614084	248528	541716	219264	(-)11.774%
Local Transplant (L.T)	1785670	722663	1695485	686164	(-)5.050%
High Yielding Variety (HYV)	11732031	4748936	11906085	4819394	(+)1.484%
Total (Broadcast+L.T.+HYV)	14131786	5720127	14143347	5724822	(+)0.082%

Furthermore, yield rates improved across all categories in 2022-23, with the most substantial gain seen in L.T. (+7.44%), suggesting that improvements in agronomic practices are benefiting both traditional and modern methods. Consequently, despite the damage from Cyclone Bulbul noted in the methodology, total Aman production increased by 3.13%, driven overwhelmingly by the growth in HYV output (+3.51%).

The Overarching Impact of Climate Change and Extreme Weather

The regression analysis of seed demand and supply from 2005-06 to 2020-21 reveals a critical long-term challenge. The demand for seeds is increasing at a rate of approximately 42,856 MT per year (Demand = 42,856x + 896,509), while supply is increasing at a much slower rate of 13,264 MT per year (Supply = 13,264x + 162,702). This growing gap underscores the intensifying pressure on the agricultural system to meet the needs of a growing population amidst environmental constraints.

Salinity Intrusion

Projections of sea-level rise (SLR) present a grave threat. By 2050, a 50 cm SLR is predicted, coupled with a temperature increase of up to 1.8°C in winter (Table 3: Prediction of SLR and temperature). This directly contributes to salinity intrusion, with devastating effects. Data shows that between 1990 and 2030, total rice production losses due to salinity are projected to increase by 38.5%, from 196.40 thousand tons to 272.00 thousand tons (Table 4: Prediction of possible loss of rice production due to salinity). The Aman season is disproportionately affected, with losses projected to surge by 50%. This aligns with the Chi-square results showing the sensitivity of Aman cultivation methods, highlighting salinity as a primary driver of crop vulnerability, particularly in coastal regions.

Table 3: Prediction of SLR and temperature in 2030 and 2050 in Bangladesh

Year	Climate change Scenarios: Sea level rise(cm)	Temperature Increase (Degree Celcias)
2030	30	+0.7 in monsoon; +1.3 in winter
2050	50	+1.1 in monsoon; +1.8 in winter

Source: On base year (1990): average winter temp: 19.90C and average monsoon temp:28.7 degree Celsius.

Sea level rise is projected to accelerate over time, with levels expected to be about 20 cm higher by 2050 than they are in 2030, representing roughly a 66.7% increase. Temperatures are also expected to climb, with monsoon temperatures rising by around 0.4°C (about 57% above the 2030 level) and winter temperatures increasing by about 0.5°C (approximately 38.5% above the 2030 level). Overall, these trends suggest that climate change impacts intensify rather than grow in a straight line, with both sea-level rise and warming appearing to speed up over time (Rahman & Rahman, 2019). Winter warming is projected to remain higher than monsoon warming in both years, although the monsoon period shows a faster rate of increase between 2030 and 2050 (Rahman & Rahman, 2019).

Table 4. Prediction of possible loss of rice production due to salinity:

Year	Loss of rice production due to salinity (in'000 ton)		
	Aus	**Aman**	**Total**
1990(Base Year)	65.60	130.80	196.40
2030	75.80	196.20	272.00

Floods and Cyclones

The impact of extreme weather events is profound and recurrent. Between 2015 and 2020, natural disasters caused crop damage worth BDT 517,961 million (BBS, 2022). Analysis of historical flood data (2007-2016) shows that all three major rice seasons Aus, Aman, and Boro have suffered massive losses in different years (Table 5: The losses of crop production due to recent floods in Bangladesh). For instance, the Boro crop, a dry-season crop reliant on irrigation, experienced a loss of 369,591 MT in 2009-10, demonstrating that no season is immune to climatic shocks.

Table- 5. The losses of crop production due to recent floods in Bangladesh:

Crop's name	Loss in production (M.ton) due to floods from 2007 to 2015:						
	2007-08	2008-09	2010-11	2009-10	2011-12	2014-15	2015-16
Aus	94164	990	--	---	7519	7077	17395
Aman	230681	113465	12580	--	70014	125250	102254
Boro	--	--	--	369591	--	--	97592
Jute	46145	--	-	--	--	--	--
Sugarcane	116387	--	--	--	--	-	--
Vegetables	99614	670	--	--	5242	79	--
Banana	7014	--	--	--	--	--	-
Pineapple	2815	--	--	--	--	--	--
Papaya	2386	30034	--	--	--	--	--
Maize	1743	745	--	--	--	--	--
Ginger	1084	--	--	--	--	--	--
Chilies	2204	622	--	--	2542	--	--

M. Ton= Metric Ton

The damage reports from specific events in the study period provide granular insight. For example, in the July 2022 floods, HYV Aman was the most severely affected crop in absolute terms, with a total production loss of 812,454 MT across Bangladesh, with districts like Rangpur and Naogaon being epicenters of damage (Table 6: Damage of different crops due to flood and excessive rain). Conversely, Cyclone Bulbul in 2019-20 caused significant damage to high-value crops like Ripe Banana in Pirojpur, resulting in a loss of 3,881 MT. This illustrates the diverse nature of climatic threats, from widespread inundation that devastates staple grains to localized cyclones that destroy cash crops.

Table 6: Damage of different crops due to flood and excessive rain in the month of July & August;

Name of crops & region	Area damaged (Acres		Percentage of partial damage	Area in terms of full damage (Caused by partial damaged	Total area damaged (Acres (Col 2	Yield per acre (Kg	Production loss in Metric Ton
	Fully	partially					
			Local Aus				
Rangamati	989	1356	18.00	244	1233	15.30	704
Sylhet	344	655	35.00	230	574	16. 20	347
Sirajganj	132	--	---	--	132	13.20	65
Bangladesh	1465	2011	24. 00	474	1939	15 .42	1116
			HYV Aus				
Noakhali	1434	1550	3.00	52	1486	23.63	1311
Rangamati	187	392	26.00	102	289	22.30	241
Maulvibazar	1257	2053	40.00	821	2078	30.30	2350
Sylhet	2391	4518	38.00	1717	4108	28.00	4294
Sirajganj	178	609	44	268	446	26.79	446
Rajshahi	24811	2382	63.00	1507	26318	29.20	28686
Naogaon	17152	7170	30.00	2151	19303	29.39	21176
Chapai Nawabganj	257	9729	45.00	4378	4635	28.10	4862
Bangladesh	47667	28403	39.00	10996	58663	28.94	63366
			Total Aus (Local+ HYV)				
Noakhali	1434	1550	3.00	52	1486	23.63	1311
Rangamati	1176	1748	20.00	346	1522	16.63	945
Maulvibazar	1257	2053	40.00	821	2078	30.30	2350
Sylhet	2735	5173	38.00	1947	4682	26.55	4641
Sirajganj	310	609	44.00	268	578	23.68	511
Rajshahi	24811	2382	63.00	1507	26318	29.20	28686
Naogaon	17152	7170	30.00	2151	19303	29.39	21176
Chapai Nawabganj	257	9729	45.00	4378	4635	28.10	4862
Bangladesh	49132	30414	38.00	11470	60602	28.50	64482
			Broadcast (Aman)				
Sirajganj	3022	9817	36.00	3534	6556	13.60	3328
Bangladesh	3022	9817	36.00	3534	6556	13.60	3328
			HYV Aman				
Jamalpur	67516	41795	45.00	18808	86324	28.90	93123
Sherpur	4711	6944	52.00	3611	8322	27.96	8685
Netrokona	15182	25328	34.00	8612	23794	28.70	25490
Mymensingh	18127	51470	12.00	6176	24303	28.80	26126
Joypurhat	14089	13839	44.00	6135	20224	31.60	23855
Rajshahi	5197	1031	51.00	529	5726	32.20	6882
Naogaon	99144	28896	38.00	10980	110124	32.95	135446

Chapai Nawabganj	937	1631	37.00	603	1540	31.17	1792
Rangpur	254421	473641	26.00	123147	377568	30.64	431828
Gaibandha	28277	49915	53.00	26455	54732	28.99	59227
Bangladesh	507601	694490	29.00	205056	712657	30.54	812454
Toal Aman (Broadcast+ HYV)							
Sirajganj	3022	9817	36.00	3534	6556	13.60	3328
Jamalpur	67516	41795	45.00	18808	86324	28.90	93123

Here is a comparative analysis of the damaged crop data. The comparison is structured by crop type (Local Aus, HYV Aus, Aman - Broadcast, Aman - HYV, and Total Aman) and key metrics such as area damaged, production loss, and yield impact.

Trends in Land Use and Crop Production

The trend analysis of agricultural land from 2019-20 to 2021-22 reveals several concerning patterns.

- **Net Cropped Area:** Decreased from 20,081 to 19,875 ('000 acres).
- **Current Fallow Area:** Increased from 1,066 to 1,206 ('000 acres).
- **Gross Cropped Area and Cropping Intensity:** All categories (single, double, triple) showed a minor decline.

These trends suggest a contraction in active agricultural land, likely due to urbanization, land degradation, and the salinization of arable land. The increase in fallow land is particularly alarming, potentially indicating farmer discouragement due to climate-induced losses or soil fertility issues. However, this is juxtaposed with a steady increase in total cereal production, which plateaued at 43,493 ('000 M.Tons) in 2020-21 and 2021-22. This indicates that productivity gains through the adoption of HYVs and improved practices are, for now, offsetting the loss of cultivated areas, but this trend may be unsustainable.

Resilience and Adaptation: Evidence from Diversified Sectors

Analysis of non-cereal sectors reveals important insights into agricultural adaptation and economic diversification.

Oilseeds and Spices

The oilseed sector shows promising growth. The grand total area under oilseed increased by 10.25% from 2020-21 to 2022-23, and production surged by 17.67%. This growth was primarily driven by Rape & Mustard, which saw a 38% increase in production, and Soybean, which saw an 18% increase. Similarly, the production of spices and condiments grew consistently, with total output rising from 3.59 million MT in 2020-21 to 4.12 million MT in 2022-23. The growth in these high-value sectors indicates a successful diversification away from an exclusive focus on rice, which enhances income security and potentially builds resilience against climate shocks that specifically affect cereals.

Drugs and Narcotics

The regression analysis for drugs and narcotics crops showed varying relationships between cultivated area and production. Betel Leaves exhibited a very strong positive linear relationship ($R^2 \approx 0.91$), while Tobacco also showed a good fit ($R^2 \approx 0.89$). However, Tea showed only a moderate correlation ($R^2 \approx 0.53$), and Betelnut a very poor one ($R^2 \approx 0.03$), the latter likely due to a dramatic reported drop in area in 2022-23 not matched by a proportional drop in production. This anomaly could indicate significant yield improvements or a data reporting issue. The overall slight decline in total area for this sector suggests other land-use pressures or shifting economic priorities.

Synthesis and Interpretation

The results collectively paint a picture of an agricultural sector under severe stress but actively adapting. The highly significant Chi-square results confirm that farmer behavior, reflected in crop variety choice and area allocation, is responsive to changing conditions. The widespread decline in local varieties in favor of HYVs is a rational response to the dual pressures of ensuring food security and adapting to climate change, given the superior yield potential of HYVs.

The projections and recorded data on salinity, sea-level rise, and extreme weather events provide the "why" behind these shifts. The gradual loss of arable land and the increasing fallow area are direct consequences of these environmental pressures. However, the resilience of the sector is evidenced by the steady cereal production despite land loss, and the robust growth in oilseeds and spices. This aligns with the literature review, which highlighted climate-resilient crop varieties and diversified farming systems as key adaptation measures.

The core of the discussion lies in interpreting the regression results on seed demand and supply. The widening gap is a stark warning. It symbolizes the growing disconnect between the escalating needs of the population and the capacity of a climate-stressed agricultural system to meet them. This analysis strongly supports the claim that under a business-as-usual scenario, the country faces significant agricultural losses, potentially up to USD 7.7 billion annually, with rice production falling by 33% in the next two decades.

In conclusion, the results confirm a statistically significant link between environmental stressors and agricultural performance in Bangladesh. The adoption of HYVs and diversification into resilient crops are positive signs of adaptation. However, the relentless pressures of salinity, extreme weather, and land degradation, compounded by a systemic gap between seed demand and supply, threaten to overwhelm these efforts. This underscores the critical need for accelerated investment in climate-smart agriculture, as outlined in the literature review, to bridge this gap and secure the future of agriculture in Bangladesh.

4. Conclusion & Recommendations:

Climate change poses significant challenges to agriculture in Bangladesh, a country heavily reliant on farming, due to increased frequency and intensity of extreme weather events like floods and droughts. These events can severely impact crop yields, leading to food insecurity. However, Bangladesh is also actively pursuing climate-resilient and green agriculture practices to mitigate these effects and enhance food production.

Bangladesh's agriculturally based economy is under increasing stress due to environmental changes, but proactive adaptation strategies, particularly green agriculture, show promising results. The government and development partners should further scale up support for climate-resilient practices, improve farmer access to climate information and technology, and invest in infrastructure for water conservation and saline-resilient crop varieties. These efforts are essential for safeguarding food security and promoting sustainable agricultural development in the face of a changing climate.

5. References

Ahmed, A., Bakhtiar, M. M., Hoddinott, J., & Roy, S. (2024). *Does nutrition-sensitive social protection build longer-term resilience? Experimental evidence from Bangladesh* (No. 2282). International Food Policy Research Institute (IFPRI). https://doi.org/10.55158/DEEPWP25

Akter, M. M., & Nasher, N. R. (2025). Climate change impact on food security: Household-level adaptation barriers to Charland community in Bangladesh. *World Development Perspectives*, *37*, 100656. https://doi.org/10.1016/j.wdp.2025.100656.

Alotaibi, M. (2023). Climate change, its impact on crop production, challenges, and possible solutions. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, *51*(1), 13020-13020.10.15835/nbha51113020

Ashrafuzzaman, M., Artemi, C., Santos, F. D., & Schmidt, L. (2022). Current and future salinity intrusion in the south-western coastal region of Bangladesh. *Spanish Journal of Soil Science*, *12*, 10017. https://doi.org/10.3389/sjss.2022.10017.

Bhuyan, M. I., Supit, I., Kumar, U., Mia, S., & Ludwig, F. (2024). The significance of farmers' climate change and salinity perceptions for on-farm adaptation strategies in the south-central coast of Bangladesh. *Journal of Agriculture and Food Research*, *16*, 101097. https://doi.org/10.1016/j.jafr.2024.101097

Bhuyan, M. S., & Raju, V. (2018). Post-Harvest losses and marketing technologies of agricultural products in Bangladesh. *International Journal of Marketing & Human Resource Management*, *9*(1), 18-30. DOI: 10.34218/IJMHRM.9.1.2018.002

Chapagain, T. R., Karki, T. B., Shah, P., Acharya, G. D., Gyeltshen, K., Islam, M. R., & Hossain, M. B. (2023). Climate-smart agriculture technologies and practices in Nepal. *SAARC Agriculture Centre, SAARC, Dhaka, Bangladesh, 82p*. ISBN Number: 978-984-35-4878-8

Chowdhury, M. M. I., Rahman, S. M., Al Amran, M. I. U., Malik, K., Abubakar, I. R., Aina, Y. A., & Hasan, M. A. (2022). Climate change impacts on food system security and sustainability in Bangladesh. https://doi.org/10.21203/rs.3.rs-1673139/v1.

Chowhan, S., Sultana, R., Md, A. R., & Islam, M. (2023). Contribution of agriculture sector in the GDP growth of Bangladesh. *Food and Agri Economics Review*, *3*(2), 51-54.doi: http://doi.org/10.26480/faer.02.2023.51.54

Debsharma, S. K., Rahman, M. A., Khatun, M., Disha, R. F., Jahan, N., Quddus, M. R., & Kabir, M. S. (2024). Developing climate-resilient rice varieties (BRRI dhan97 and BRRI dhan99) suitable for salt-stress environments in Bangladesh. *Plos one*, *19*(1), e0294573. https://doi.org/10.1371/journal. pone.0294573

Feist, S. E., Hoque, M. A., Islam, M. A., Dewan, A., & Fowler, M. (2025). Sea-level rise drives changes in salinisation patterns in low-lying Bangladesh. *Ecological Indicators*, *176*, 113543. https://doi.org/10.1016/j.ecolind.2025.113543.

Ferdushi, K. F., Ismail, M. T., & Kamil, A. A. (2019). Perceptions, knowledge and adaptation about climate change: A Study on farmers of Haor areas after a flash flood in Bangladesh. *Climate*, *7*(7), 85. https://doi.org/10.3390/cli7070085

Habib, M. A., Babur, K. A. R., Islam, M. M., Akter, N., Bari, M. S., Bashir, M. A., & Ali, M. M. (2025). Climate Change Dynamics and Their Effects on Bangladeshi Agriculture: A Systemic Review. *Nature-Based Solutions*, 100275. https://doi.org/10.1016/j.nbsj.2025.100275

Hasan, M. K., Desiere, S., D'Haese, M., & Kumar, L. (2018). Impact of climate-smart agriculture adoption on the food security of coastal farmers in Bangladesh. *Food Security*, *10*(4), 1073-1088. https://doi.org/10.1007/s12571-018-0824-1

Hossain, M. S., Dearing, J. A., Rahman, M. M., & Salehin, M. (2016). Recent changes in ecosystem services and human well-being in the Bangladesh coastal zone. *Regional Environmental Change*, *16*(2), 429-443.DOI 10.1007/s10113-014-0748-z

IPCC. (2022). *Climate change 2022: Impacts, adaptation and vulnerability. Working Group II contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press.https://www.ipcc.ch/report/ar6/wg2/?utm

Islam, M. D., & Eusuf, M. A. (2025). Analysing the National Plans of Bangladesh for Their Effectiveness in Mitigating Socio-economic and Environmental Vulnerabilities in Char Areas. *Asia-Pacific Journal of Rural Development*, *35*(1), 112-131. https://doi.org/10.1177/10185291251343346.

Khan, M. Z., & Shoumik, B. A. (2022). Land degradation neutrality concerns in Bangladesh. *Soil Security*, *9*, 100075. https://doi.org/10.1016/j.soisec.2022.100075

Kibria, G., Pavel, H. R., Miah, M. R., & Islam, M. R. (2022). Impacts of climate change in Bangladesh and its consequences on public health. *Journal of Sustainability and Environmental Management*, *1*(3), 359-370. Available online at https://www.nepjol.info/index.php/josem

Majumder, M. K., Rahman, M., Mondal, R. K., & Akter, M. (2024). Climate-smart agriculture and food security in climate-vulnerable coastal areas of Bangladesh. *Heliyon*, *10*(22). https://doi.org/10.1016/j.heliyon.2024.e39885

Miah, M. Y., Kamal, M. Z. U., Salam, M. A., & Islam, M. S. (2020). Impact of salinity intrusion on agriculture of Southwest Bangladesh-A review. *International Journal of Agricultural Policy and Research*. https://doi.org/10.15739/IJAPR.20.005

Nandi, R., Krupnik, T. J., & Kabir, W. (2024). Crop diversification in Bangladesh: Public policy provisions, practices, and insights for future initiatives. *Journal of Agriculture and Food Research*, *18*, 101486. https://doi.org/10.1016/j.jafr.2024.101486

Pathak, H., Pal, B. D., & Joshi, P. K. (2018). Climate change induced salinity intrusion and its implications for agriculture. https://cgspace.cgiar.org/server/api/core/bitstreams/3ae25eea-b6e4-4238-a930-261d5921843b/content

Pervez, M., Ahmed, Z., Uddin, M. S., & Rahman, M. M. (2024). Agricultural Output and Economic Growth Nexus: A VECM Approach on Bangladesh. *Journal of Agricultural Sciences*, *30*(4), 644-657.doi: 10.15832/ankutbd.1388810

Quddus, A., & Kropp, J. D. (2020). Constraints to agricultural production and marketing in the lagging regions of Bangladesh. *Sustainability*, *12*(10), 3956. https://doi.org/10.3390/su12103956

Rahman, M. S., & Rahman, M. A. (2019). Impacts of climate change on crop production in Bangladesh: a review. *Journal of Agriculture and Crops*, *5*(1), 6-14. doi: https://doi.org/10.32861/jac.51.6.14

Rahman, J., Foisal, M. Z. U., Mohajan, B., & Islam, S. (2022). Nexus between agriculture, economy, energy use, and ecological footprint toward sustainable development in Bangladesh. *Journal of environmental and energy economics*, *1*(2), 18-31. DOI: 10.56946/JEEE.V1I2.486

Rahman, M. M., Chowdhury, M. M. I., Al Amran, M. I. U., Malik, K., Abubakar, I. R., Aina, Y. A., & Rahman, S. M. (2024). Impacts of climate change on food system security and sustainability in Bangladesh. *Journal of Water and Climate Change*, *15*(5), 2162-2187.doi: 10.2166/wcc.2024.631

Rayhan, S. J., Rahman, M. S., & Lyu, K. (2023). The role of rural credit in agricultural technology adoption: The case of Boro rice farming in Bangladesh. *Agriculture*, *13*(12), 2179. https://doi.org/10.3390/agriculture13122179

Ruba, U. B., Talucder, M. S. A., Zaman, M. N., Montaha, S., Tumpa, M. F. A., Duel, M. A. K., & Triza, A. H. (2024). The status of implemented climate smart agriculture practices preferred by farmers of haor area as a climate resilient approach. *Heliyon*, *10*(4).

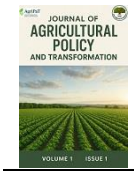
Saleem, A., Anwar, S., Nawaz, T., Fahad, S., Saud, S., Ur Rahman, T., & Nawaz, T. (2025). Securing a sustainable future: the climate change threat to agriculture, food security, and sustainable development goals. *Journal of Umm Al-Qura University for Applied Sciences*, *11*(3), 595-611.https://doi.org/10.1007/s43994-024-00177-3

Sheikh, M. M., & Pervez, A. K. M. K. (2025). Climate change and agriculture in Bangladesh: impacts and adaptation

strategies: Climate Change and Agricultural Adaptation in Bangladesh. *Bangladesh Journal of Agriculture*, *50*(1), 132-148. Tasnim, I., Iqbal, M. A., Begum, I. A., Alam, M. J., Graversgaard, M., Sarma, P. K., & Manevski, K. (2025). Household resilience and its role in sustaining food security in rural Bangladesh. *PLoS One*, *20*(9), e0332868. https://doi.org/10.1371/journal.pone.0332868

Uddin, M. M., & Hoque, M. A. (2025). Climate Change Trends and Vulnerabilities in Bangladesh's Crop Sector: A Review of Crop Production Challenges and Resilience Strategies. *Turkish Journal of Agriculture-Food Science and Technology*, *13*(2), 258-272. DOI: https://doi.org/10.24925/turjaf.v13i2.258-272.6923

World Bank. (2024). *Bangladesh Climate-Smart Agriculture and Water Management Project: Supporting farmers with technology for increased productivity and climate resilience* (Project document). World Bank. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/099055401032414144?



Journal of Agricultural Policy and Transformation (AgriPaT)

Journal homepage: http://www.ageconfrontiers.com/agripat

The Role of Defence Savings Certificates in Pakistan's GDP Performance

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ARTICLE INFO

Keywords:
Defence Savings Certificates (DSCs)
National Savings Organisation (NSO)
Gross Domestic Product (GDP)
Gross Capital Formation (GCF)
Gross Domestic Savings (GDS)
State Bank of Pakistan (SBP)

Received: 06 October 2025

Received in revised form: 19 November 2025

Accepted: 23 December 2025

Available online: 24 December 2025

ABSTRACT

This study empirically investigates the impact of Defence Saving Certificates (DSCs) on Pakistan's gross domestic product (GDP), addressing an important gap in the literature on domestic savings instruments and macroeconomic performance. DSCs are government-sponsored, low-risk financial instruments administered by the National Savings Organisation (NSO) and are designed to mobilize household savings for public financing. Despite their widespread use and fiscal importance, their specific contribution to economic growth has remained underexplored in empirical research.

Using annual time-series data spanning the period from 1990 to 2024, this study applies an Autoregressive Integrated Moving Average (ARIMA) modeling framework to examine the dynamic relationship between GDP, DSC investments, gross capital formation (GCF), and gross domestic savings (GDS). The results indicate a statistically significant and positive relationship between DSCs and GDP, suggesting that increased investment in these certificates contributes meaningfully to overall economic output by channeling domestic savings into productive public use. Consistent with economic theory, GCF also exhibits a strong positive effect on GDP, reflecting the role of investment in driving growth. In contrast, GDS does not show a significant direct relationship with GDP within the estimated model, implying that savings alone may not translate into growth without effective financial intermediation.

The study concludes that DSCs represent an effective fiscal and financial instrument for supporting economic growth in Pakistan. It recommends policy measures to enhance their accessibility, expand digital platforms, and strengthen the institutional capacity of the NSO to better harness domestic savings for sustainable national development.

1. Introduction

Domestic savings are the cornerstone of economic growth and development (Wanzala and Obokoh, 2024) by providing the capital that works as fuels in investment and enhance growth. The strong link between a national savings and its investment levels has long been documented in economic theory (Feldstein and Horioka, 1980). Investment, enhances productivity, encourages innovation, and sustains long-term economic expansion. For developing economies such as Pakistan, strong domestic savings are even more essential. They reduce dependence on unpredictable external borrowing and promote lasting macroeconomic stability (Khan *et al*., 1998).

The saving is the holdings in backward societies whereas in developed and dynamic economies, savings is an important factor of development, which we call Investment. From an economic point of view, saving is that part of income that is not spent on consumption (Mankiw, 1998). Lord J.M. Keynes, enumerates three motives of savings, (i) Speculative Motive (ii) Business Motive and (iii) To Meet Emergency. Savings can be viewed from various perspectives, including that of an individual, a family, a business, or an entire country (Keynes, 1937). When considered from the national or country level, these savings are referred to as "National Savings or domestic savings". National Savings organization as it stands today is one of

the primeval institutions in the country with a legacy of more than 140 years that came into existence with the promulgation of the Government Savings Bank Act in 1873 (Tumbe, 2015). During World Wars I and II, the British Government used this channel to raise funds to meet war related expenditures. Given the effectiveness and net benefits of these initiatives, the idea of institutionalizing the savings culture was materialized by setting up a National Savings Bureau in 1943-44 as an attached department of the undivided Government of India. Since acquiring independence in 1947, this organization remained operational in Pakistan in different forms. This Bureau was renamed as Central Directorate of National Savings in 1953 (National Savings, 2025). In 1960, it was decided to rejuvenate the structure of CDNS by declaring the status of an Attached Department of the Pakistan's Ministry of Finance with the powers to formulate policies and execute various National Savings Schemes (Khan, 2024).

In this context, the National Savings Organization (NSO) has played a central role in mobilizing Pakistan's domestic resources. A key turning point came in 1972, when the NSO was granted authority to manage both policy and implementation for various National Savings Schemes (NSS). Through these schemes, the organization has designed financial instruments tailored to a diverse range of investors, encouraging financial inclusion while channeling household savings into productive government use (Malhotra, 1956).

Among these instruments, the Defence Saving Certificates (DSCs), launched in 1966, stand out as a secure, government-backed investment option. They not only offer individuals a low-risk savings avenue but also help the state meet its long-term financing needs for development and budgetary support. Yet, despite their long-standing presence in Pakistan's financial landscape, surprisingly little empirical research has examined how DSCs influence key macroeconomic indicators such as Gross Domestic Product (GDP). While theory clearly links savings to growth, the real question is: do specific state-managed savings tools like DSCs truly drive economic expansion or merely finance fiscal deficits? Previous studies offer mixed answers. Some suggest that national savings schemes primarily support government borrowing rather than directly stimulating growth (Feltenstein and Iwata, 2002).

This study seeks to clarify that uncertainty by asking: Do Defence Saving Certificates have a statistically significant and direct impact on Pakistan's GDP, independent of general savings and investment trends. By addressing this question, the research aims to provide policymakers with evidence-based insights on how to strengthen the NSO's contribution to Pakistan's broader development strategy.

2. LITERATURE REVIEW

For times, economists have tangled with a misleadingly simple question that "how exactly do a nation's savings fuel its economic growth?" The search for its answer has spun a global web of studies, each one adding a piece to a puzzle that is anything but straightforward.

The connotation between national savings and economic growth is a subject that has been broadly discussed and investigated, thus it presents a tapestry of insights across various economic contexts. The seminal contribution of (Feldstein and Horioka, 1980) actually focused on the high association between domestic savings and investment within OECD countries, thus indicating limited international capital mobility and reinforcing the importance of domestic savings and domestic investment. Dynamics among developing countries, however, are often different. Specific research on Pakistan's savings schemes has also produced mixed results. Pakistan offered a particularly curious case. An early investigation by (Feltenstein and Iwata, 2002), zoomed in on the country's National Saving Scheme (NSS). Sifting through data from the State Bank and economic surveys, they concluded the scheme's overall effect was murky. Its real importance was not in directly powering growth, but in plugging the hole between what the government spent and what it earned. They made two fascinating discoveries: people often treated NSS deposits and regular bank accounts as interchangeable, and demand for the NSS was strangely tied to foreign currency deposits. The numbers from 1991 to 1996 revealed why: with the average NSS return at 11.69% and dollar deposits paying 14.19%, that 2.5% gap showed how savers were swayed by the strength of the US dollar. This idea that government-backed savings plans are not a cure, found support in the work of (Attanasio and DeLeire, 2002) that same year. They contended that even popular tax-break accounts like IRAs in the United States only added, at the very most, a modest 9% to the country's total savings, a figure they pulled from historical spending data. As researchers broadened their view to other countries, the plot thickened.

Nnanna (2003) explained that savings play a foundational role in capital accumulation and long-term economic development. High savings rates allow higher levels of investment, which in turn make stronger productive capacity and overall national growth. The study emphasized that savings behaviour is strongly influenced by income levels, inflation expectations, interest rate structure, and the efficiency of financial institutions.

In Ghana, a study by (Asamoah, 2008) used regression analysis to measure the impact of financial reforms. Studies results pointed to a powerful link between real interest rates

and private investment. The connection was so strong that only 1 percent rise in the real interest rate would trigger an 8.2 percent jump in private investment that highlights how crucial financial incentives are for channeling savings into productive projects.

Back in Pakistan, the analytical tools grew more advanced. (Sajid and Sarfaraz, 2008) used data from 1973 to 2003 and applied sophisticated Co-integration models. They uncovered a critical nuance: while savings led to growth in the long-run, the short-term story supported the Keynesian view that savings levels are actually a consequence of the current level of output or GDP. (Ahmad and Mahmood, 2013) pushed this challenge to traditional economic thinking further. Focusing on Pakistan from 1974 to 2010, they used an Autoregressive Distributed Lag model and arrived at a provocative finding: per capita income and its growth were an inverse function of national savings. In simpler terms, as the country's income grew, the proportion of income being saved did not necessarily follow suit-it might even fall. Finally found a note of resolution in the work of (Najarzadeh *et al*., 2014), Study from Iran, from 1972 to 2010 with a similar model, they found clear evidence of a two-way relationship, means that in the long haul, their work confirmed a virtuous cycle where savings and economic growth feed into and strengthen one another. Intertwined together, these studies create a rich tapestry of insight. They tell us that the link between saving and growth is not a simple lever to pull, but a dynamic influenced by policy, incentives, currency, and time itself whose steps change in every economy.

Same like that, (Nabi and Billah, 2024) examines the role of remittances inflow on GDP growth and inflation influences national savings in south Asian economies. Study revealed that remittances have significant and positive effect on national savings while GDP growth and migration rate have positive relationship. Adding to this global perspective, a recent study by (Wanzala and Obokoh, 2024) examines the nexus between domestic savings and sustainable economic growth in South Africa. Study findings indicate that corporate savings significantly boost long-run economic growth, while household and government savings exhibit insignificant long-run effects.

This review also highlights that the relationship between savings and growth is not monolithic; rather, it is mediated by policy, institutional factors, and economic context. There is also a clear gap in the literature on the exact impact of individual savings instruments, such as Defence Saving Certificates, on GDP. This study contributes to this discourse by focusing specifically on this instrument within Pakistan's unique economic environment.

3. Materials and Methods

Research Design and Data Sources

This study uses quantitative time series data to examine the impact of Defence Savings Certificates (DSC) on Pakistan's GDP**.** Secondary data is collected from various sources, including government financial institutions and economics reports. The primary source of data is from State bank of Pakistan, National savings organisation and Historical data of Defence saving Certificates (DSC) issuance, Gross Domestic Product (GDP), Government Capital Formation (GCF) and Gross Domestic Savings (GDS) were analyzed. Historical data of DSC's, GDP, GCF, GDS and DSC from the fiscal year of 1990 to 2024.

Variables:

In this study, the dependent variable is Pakistan's GDP, measured in million rupees. The independent variables include Defence Savings Certificates (DSC) measured in million rupees, Gross Domestic Savings (GDS) measured in billion US dollars, and Gross Capital Formation (GCF) measured in trillion US dollars. These variables are used to examine how changes in savings instruments and investment-related indicators are associated with variations in Pakistan's GDP over time.

Sources of data

For this study are taken from official and reliable databases. Gross Domestic Product (GDP) data is obtained from State Bank of Pakistan financial reports and the Economic Survey of Pakistan. Defence Savings Certificates (DSCs) data is collected from State Bank of Pakistan financial reports, the Economic Survey of Pakistan, and National Savings Organisation financial reports. Gross Domestic Savings (GDS) data is taken from the World Bank database, while Gross Capital Formation (GCF) is sourced from the World Bank datasheets.

Econometric Model:

In this study, the econometric analysis is conducted using the Autoregressive Integrated Moving Average (ARIMA) model, estimated in SPSS (version 22). ARIMA is a univariate time-series technique that captures dependence in the data through autoregressive (AR) and moving average (MA) components, while ensuring stationarity through differencing (the "I" term). The appropriate ARIMA specification is selected by examining the series for stationarity and using autocorrelation (ACF) and partial autocorrelation (PACF) patterns, supported by information criteria such as AIC and BIC. Model parameters are then

estimated in SPSS, and diagnostic tests (e.g., residual normality and independence checks such as the Ljung–Box Q statistic) are used to confirm that the residuals behave like white noise. Once validated, the final ARIMA model is employed to generate forecasts and evaluate the time-series behavior of the study variable.

4. Results and Discussion

Results

This section discusses the essential findings that highlight the significance of Defence Saving Certificates (DSCs) in the GDP performance of Pakistan. Employing the time-series approach, the findings are outlined to illustrate the trends and implications that emerge, first, into the relationship between the DSC and GDP, and, therefore, the implications that arise out of this relationship for economic performance. Essentially, the significance of this section not only lies in identifying the outcomes that arise out of the empirical findings, but also the implications that arise out of these findings to not only interpret the results, but to position them within the economic framework that Pakistan follows with regard to savings and government borrowing.

Table 1: Model Summary Model summary of Defence Saving Certificates, Pakistan GDP, GDS and GCF

Model		Model Fit statistics	
	Number of Predictors	Stationary R-squared	R-squared
Gross Domestic Product	3	0.672	0.672

In this table 1, it shows the overall goodness of fit estimated for Pakistan's GDP using three predictors that are Defence Savings Certificates, Gross Domestic Savings (GDS) and Gross Capital Formation (GCF). These three predictors means that three independent variables are included in the model to explain variation in the Pakistan's GDP. R-Square is 0.672 which shows that 67.2% of variation in GDP is explained by these predictors and the stationary R-squared, which is also 0.672, confirms that the model maintains its explanatory power after accounting for stationarity in the time-series data.

Table 2: Estimated ARIMA Model Coefficients for GDP and Key Predictors (DSCs, GDS, and GCF)

ARIMA Model Parameters				
	Estimate	**SE**	**t**	**Sig.**
Gross Domestic Product	-16556004.79	7582159.351	-2.184	0.037
Defence savings certificates	85.686	33.998	2.52	0.017
Gross Domestic Savings	-324037.366	693625.114	-0.467	0.644
Gross Capital Formation	753312.461	280424.871	2.686	0.012

Table 2 presents the estimated the ARIMA parameter shows that the intercept GDP is negative and statistically significant ($p = 0.037$) that indicates a meaningful effect when all predictors are held constant and coefficient for Defence Saving Certificates is positive and statistically significant at the 5 percent level of significance ($\beta = 85.686$, $p = 0.017$). This finding implies that an increase in investment through Defence Saving Certificates contributes positively to Pakistan's economic growth. The result highlights the role of government backed saving instruments in mobilizing domestic resources and supporting GDP expansion. While, Gross Domestic Savings exhibits a negative but statistically insignificant relationship with GDP ($\beta = -324{,}037.366$, $p = 0.644$). Domestic savings do not exert a significant direct influence on economic growth. Finally, Gross Capital Formation shows a positive and statistically significant impact on GDP ($\beta = 753{,}312.461$, $p = 0.012$), this result indicates that increased investment in

physical capital plays a crucial role in enhancing economic output, consistent with classical and endogenous growth theories. These findings demonstrate that Defence Saving Certificates and Gross Capital Formation are significant drivers of Pakistan's GDP, while Gross Domestic Savings does not significantly affect economic growth in the estimated ARIMA framework.

Discussion

The empirical results of this study provide insight into the distinct role various forms of savings play in the economic ecosystem of Pakistan. The strong positive relationship between DSCs indicates that targeted government-directed savings instruments work well. Capital mobilized through DSCs is efficiently channeled into the fiscal system, where it is most likely used for public investment in infrastructure and other development projects or to finance budgetary deficits in a manner that sustains aggregate demand. This direct channel from household savings to government spending translates into a noticeable and measurable stimulus to national output.

The contrasting outcome for GDS, which shows an insignificant relationship, deserves careful interpretation. This does not mean that savings are unimportant for growth. What this says is that aggregate domestic savings, if not intermediated appropriately by the financial system, may not get transformed into productive capital formation within the model's framework. This could be due to a number of structural factors in the Pakistani economy:

Heavy domestic borrowing by the government may use up most of the available funds in the market, thereby perhaps increasing interest rates and reducing credit to private investors. A large portion of GDS can be held in unproductive assets, such as real estate, gold, or foreign currency kept outside the formal banking sector and thereby not contributing to the pool of investable capital. In a country with limited social safety nets, a large fraction of household savings may be precautionary, held in liquid forms with the purpose of buffering against income shocks rather than being committed to long-term investment.

5. Conclusion

The ensuing study establishes quite conclusively that Defence Saving Certificates are a major and positive determinant of GDP growth in Pakistan. By offering a safe and attractive avenue for investment, DSCs effectively mobilize inactive domestic capital and route it directly into the government's development financing stream with a tangible macroeconomic return. The findings thus confirm the continued relevance of the National Savings Organisation as an institution for fiscal stability and growth. The strong, positive impact of the GCF reinforces fundamental economic theory, since GCF represents direct investment in physical capital, which expands the economy's capacity for production. The insight behind the findings along this critical distinction while GDS represents potential for investment, DSCs, part of government savings, and GCF represent actualized investment emphasizes the NSO's role: an efficient intermediary in directly converting public trust into fiscal fuel for growth. However, the neutral result for GDS points to inefficiencies in the broader financial system's ability to mobilize and allocate general savings towards productivity, enhancing investments.

Policymakers should actively enhance the appeal of DSCs through digital accessibility, including a dedicated mobile application for investment, management, and profit withdrawal. Targeted financial literacy campaigns for middle- and lower-income households can deepen penetration and financial inclusion. The government should address operational bottlenecks facing the NSO. This means increasing staff strength and reviewing compensation structures to be competitive with other financial institutions, hence improving service delivery and morale. More so, investment in IT infrastructure and acquiring owned premises for key offices will improve operational efficiency and increase public trust. The insignificant finding on GDS indicates the urgency of broader financial sector reforms to improve the overall efficiency of financial intermediation. Policy should ensure that banks and capital markets channel national savings to private sector investment in a manner that would provide a more balanced and robust investment structure.

Despite these efforts, financial sector distress, though reduced and continues to affect public confidence and undermines savings mobilization. High inflationary expectations encourage immediate consumption and reduce incentives to save. Low returns on manufacturing and productive investments divert funds away from real sectors toward alternative assets. Furthermore, institutional weaknesses such as inadequate micro-credit frameworks, corruption, and weak financial governance continue to limit Pakistan's ability to foster strong savings and investment culture. Strengthening indigenous cooperative systems and enhancing the credibility of financial institutions remain critical steps toward improving savings behavior.

Deem it wise to say that National Saving Organization plays an important role in the development of Pakistan. It is backbone of our economy. This organization prevents holding of money of the people and brings it to circulation.

Which is mandatory for economic growth of the country. On the other side, people who cannot do business for lack of experience can invest in this organization and get handsome profit. On the third side, this organization off sets the rising prices and inflation.

Limitations and Avenues for Future Research

Limitations:

This study has recognized a number of limitations: using macro-level, aggregate data masks important heterogeneous investor behaviors and regional disparities in the diffusion of DSCs; although key variables have been considered, the model may not catch other factors affecting GDP, including political stability, workers' remittances, or terms of trade shocks, probably due to omitted variable bias.

Future Research Avenues

The results open several promising avenues for future investigation. Future studies might, apply the Granger causality tests, which can more clearly determine the direction of influence between the DSCs and GDP. Use household survey data to conduct micro-econometric analyses that profile DSC investors and their savings motivations and constraints. Compare the cost effectiveness and growth impact of DSCs versus other government debt instruments, such as Treasury Bills and Pakistan Investment Bonds.

6. References

Ahmad, K., & Mahmood, H. (2013). Macroeconomic determinants of national savings revisited: A small open economy of Pakistan. World applied sciences journal, 21(1), 49-57.

Asamoah, G. N. (2008). The impact of the financial sector reforms on savings, investments and growth of gross domestic product (GDP) in Ghana. International Business & Economics Research Journal (IBER),7(10).

Attanasio, O. P., & DeLeire, T. (2002). The effect of individual retirement accounts on household consumption and national saving. The Economic Journal, 112(481), 504-538.

Feldstein, M., & Horioka, C. (1980). Domestic saving and international capital flows. The economic journal, 90(358), 314-329.

Feltenstein, A., & Iwata, S. (2002). Why is it so hard to finance budget deficits? Problems of a developing country. Journal of Asian Economics, 13(4), 531-544.

Keynes, J. M. (1937). The general theory of employment. The quarterly journal of economics, 51(2), 209-223.

Khan, A. H., Nasir, Z. M., & Khan, A. H. (1998). Stylised Facts of Household Savings: Findings from the HIES 1993-94 [with Comments]. The Pakistan Development Review, 749-763.

Khan, S. A. (2024). Microcovariates of Savings in Pakistan. Pakistan Economic Review, 7 (2) PP. 48-65

Malhotra, K. S. (1956). The National Savings Organisation. Indian Journal of Public Administration, 2(4), 359-368.

Mankiw, N. G. (1998). Principles of microeconomics (Vol. 1). Elsevier.

Nabi, M. N., & Billah, M. (2024). Impact of Remittance flows on national savings: The role of GDP growth, migration rate, and inflation in south Asian countries. Journal of Agricultural and Rural Research, 6(2), 109-120.

Najarzadeh, R., Reed, M. and Tasan, M., 2014. Relationship between savings and economic growth: The case for Iran. Journal of International Business and Economics, 2(4), pp.107-124.

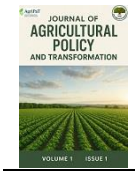
National Savings. (2025). Online available at: https://savings.gov.pk/

Nnanna, O. J. (2003). Promoting savings and investment culture for national development. Economic and Financial Review, 41(3), 3.

Sajid,G.M., and M.Sarfaraz (2008). "Savings and Economic Growth in Pakistan: An Issue of Causality," Pakistan Economic and Social Review, Vol. 46, p. 17-36.

Tumbe, C. (2015). Towards financial inclusion: The post office of India as a financial institution, 1880–2010. The Indian Economic & Social History Review, 52(4), 409-437.

Wanzala, R. W., & Obokoh, L. O. (2024). Savings and sustainable economic growth nexus: A South African perspective. Sustainability, 16(20), 8755.



Journal of Agricultural Policy and Transformation (AgriPaT)

Journal homepage: http://www.ageconfrontiers.com/agripat

Digital Banking Beyond Access: Institutional and Adoption Dynamics of FinTech in South and Southeast Asia

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ARTICLE INFO

Keywords:
Digital Banking
FinTech Institutional Design
Agriculture
Financial Inclusion
Pakistan
South Asia

Received: 12 December 2025

Received in revised form: 22 December 2025

Accepted: 24 December 2025

Available online: 26 December 2025

ABSTRACT

Digital banking and financial technology (FinTech) have become central to financial system modernization in emerging economies, yet their developmental impact depends on institutional design, sectoral integration, and user adoption. While several South Asian countries have embedded digital finance within coherent, sector-specific policy frameworks, Pakistan's experience remains uneven, with digital banking expansion showing limited linkage to productive economic activities. This study examines Pakistan's digital banking landscape from a comparative institutional perspective, using agriculture as a focal sector to assess how institutional coordination and adoption behavior shape FinTech outcomes.

The study employs an exploratory mixed-methods approach, combining cross-country secondary indicators (2018–2024) from Pakistan, India, Bangladesh, and Malaysia with primary survey evidence from digital banking users in Pakistan. Rather than testing causal relationships, the analysis evaluates patterns of association between digital banking penetration, institutional coherence, and sectoral engagement, interpreted through Financial Intermediation Theory, the Technology Acceptance Model, and Innovation Diffusion Theory.

Findings show that despite initiatives such as Raast and the Kissan Card, digital banking usage in Pakistan remains largely transactional and urban-centered, with limited integration into agricultural finance. Comparative evidence indicates that countries with stronger institutional alignment and sector-specific digital finance strategies achieve deeper productive engagement. Survey results further highlight behavioral constraints, including trust deficits, limited awareness, and gender-based access disparities in rural areas.

The study concludes that FinTech-enabled digital banking is not inherently transformative; its effectiveness depends on institutional embedding, interoperability, and sustained user engagement to support inclusive and productivity-oriented development.

1. Introduction

The rapid expansion of financial technology (FinTech) and digital banking has coincided with significant changes in financial systems worldwide, reshaping how financial services are delivered, accessed, and regulated. What initially emerged as a supplementary innovation is increasingly positioned as a central component of contemporary financial ecosystems, particularly in developing and emerging economies. Digital financial services such as mobile payments, electronic wallets, and branchless banking are commonly linked to lower entry barriers to formal finance for households and small enterprises previously excluded from traditional banking systems. As digital ecosystems mature, FinTech is increasingly viewed as a strategic enabler of sustainable development, with implications extending beyond the financial sector into productive economic activities, including agriculture (Khan & Ahmed, 2022).

Regional peers such as India, Bangladesh, and Malaysia exhibit contrasting institutional and regulatory approaches to digital financial development, offering useful benchmarks for evaluating Pakistan's digital banking trajectory within comparable developing-economy contexts (Somuncu, 2025; Rao et al., 2023). These countries represent differing stages of FinTech institutionalization rather than exhaustive regional coverage, with variations in regulatory coordination, governance capacity, and sectoral integration

shaping adoption outcomes (World Bank, 2023). Differences are evident not only in levels of technological uptake but also in the alignment between financial regulators, digital infrastructure agencies, and sector-specific ministries, particularly in agriculture and small-enterprise finance (Jena, 2025). Comparative analysis of these models enables clearer assessment of how institutional design influences digital finance outcomes and situates Pakistan's experience within a broader regional and policy context rather than in isolation (Somuncu, 2025).

Despite rapid expansion in digital financial services, Pakistan continues to lag behind comparable economies in translating FinTech growth into broad-based financial inclusion and productive economic use (SBP, 2023; World Bank, 2023). Digital banking adoption remains concentrated in urban areas, while rural uptake particularly among smallholder farmers remains limited (Malik & Sikarwar, 2025). Fragmented institutional coordination, uneven regulatory implementation, and weak linkages between financial authorities and sectoral agencies, especially in agriculture, are frequently identified as factors constraining the effectiveness of digital finance initiatives (Hussain et al., 2025; Somuncu, 2025). These challenges are especially significant given Pakistan's demographic structure, where a substantial proportion of the population resides in rural areas and relies directly or indirectly on agriculture for livelihoods (World Bank, 2023).

Agriculture remains central to Pakistan's economic and social structure, yet productivity growth has stagnated over time due to persistent structural constraints (FAO, 2022; World Bank, 2023). Limited access to formal credit, delayed subsidy disbursement, and enduring information asymmetries across agricultural value chains are widely associated with restricted investment capacity, heightened risk exposure, and weak responsiveness to market signals (Perveen et al., 2021; Chaiya et al., 2023). FinTech-enabled digital banking is frequently discussed as a mechanism with potential to ease some of these constraints by improving transparency, reducing transaction costs, and strengthening farmers' integration into formal financial systems when effectively embedded within agricultural finance frameworks (Kshetri, 2021; Hussain et al., 2025).

However, FinTech expansion does not inherently generate inclusive or productivity-enhancing outcomes. Evidence from developing economies suggests that adoption alone is insufficient where structural barriers such as low digital literacy, trust deficits, infrastructure gaps, and weak institutional support remain unresolved (Osahon, 2025). These constraints significantly limit FinTech's transformative potential in rural and agriculture-dependent regions, where socioeconomic and behavioral factors interact with regulatory capacity (Kshetri, 2021; Jena, 2025). Consequently, empirical relationships between FinTech penetration and agricultural productivity should be interpreted within broader institutional, regulatory, and behavioral contexts rather than as purely technological effects (Rao et al., 2023).

Against this backdrop, this study examines the relationship between FinTech innovation, digital banking penetration, and agricultural productivity in Pakistan, using comparative evidence from India, Bangladesh, and Malaysia. Employing a mixed-methods approach, the study combines cross-country secondary data (2018–2024) with primary survey evidence from digital banking users in Pakistan. Guided by Financial Intermediation Theory, the Technology Acceptance Model, and Innovation Diffusion Theory, the analysis explores both institutional and behavioral mechanisms through which digital finance is statistically associated with agricultural productivity outcomes. Specifically, the study asks: how and under what institutional and behavioral conditions does FinTech-enabled digital banking to translate into measurable agricultural productivity gains in Pakistan, and how does this relationship compare with regional peers?

2. Contribution of the Study

Unlike existing narrative or access-focused studies, this paper advances an analytically structured and empirically tested examination of the FinTech–agriculture nexus in developing economies. Rather than treating FinTech adoption as a uniform productivity driver, the study demonstrates how institutional coherence and user-level adoption dynamics condition the strength and effectiveness of FinTech's relationship with agricultural outcomes. The paper makes three key contributions to the literature on FinTech, financial inclusion, and agricultural development.

First, it addresses a significant gap in existing research by empirically linking FinTech diffusion and digital banking penetration with sector-specific productivity outcomes rather than limiting analysis to general financial inclusion indicators. While prior studies have examined FinTech adoption or agricultural finance independently, systematic evidence connecting digital finance expansion with agricultural productivity, particularly in South Asia, remains limited. By demonstrating a statistically significant association between digital banking penetration and agricultural output per worker, this study advances understanding of FinTech's role in real-sector performance.

Second, the study contributes through a comparative institutional framework that contrasts Pakistan's FinTech ecosystem with India, Bangladesh, and Malaysia. By examining countries at different stages of FinTech maturity, the paper highlights how institutional coherence, regulatory coordination, and sectoral integration condition the effectiveness of digital finance in agriculture. This comparative approach moves beyond single-country analyses and provides transferable policy insights for developing economies with large rural populations.

Third, the study integrates macro-level cross-country indicators with micro-level behavioral evidence from primary survey data collected in Pakistan. This mixed-methods design bridges institutional conditions with user adoption dynamics, strengthening the connection between theory, empirical strategy, and findings. By jointly applying Financial Intermediation Theory, the Technology Acceptance Model, and Innovation Diffusion Theory, the paper provides a comprehensive explanation of how FinTech-enabled financial inclusion can translate under appropriate institutional and behavioral conditions into agricultural productivity gains.

Together, these contributions position the study as an analytically grounded and policy-relevant examination of FinTech-enabled agricultural transformation in developing economies.

3. Literature Review and Theoretical Framework

Theoretical Foundations of FinTech and Digital Banking

Digital finance represents an evolution of traditional financial intermediation, where technological innovation alters how financial services are produced, delivered, and accessed. Financial Intermediation Theory (FIT) emphasizes the role of financial institutions in reducing transaction costs and information asymmetries between savers and borrowers (Levine, 1997). In digital contexts, fintech platforms extend these functions by automating intermediation processes, lowering operational costs, and expanding outreach to underserved populations. Empirical studies suggest that fintech-enabled intermediation is associated with improved efficiency, transparency, and allocation of financial resources, particularly in environments where conventional banking infrastructure is limited (Nguyen & Vo, 2023). The macro-institutional role of FIT and its key analytical variables are summarized in Table 1.

While institutional efficiency is a necessary condition, it does not alone ensure adoption or effective usage of digital financial services. The Technology Acceptance Model (TAM) provides a behavioral framework explaining individual adoption decisions through perceived usefulness and perceived ease of use (Davis, 1989). In digital banking environments, these perceptions are shaped by trust, security, usability, and digital literacy. Empirical evidence from South Asia indicates that concerns related to fraud, system reliability, and limited user familiarity significantly influence sustained usage of fintech services (Rahman et al., 2023). as reflected in the micro-level analytical mapping presented in Table 1.

Innovation Diffusion Theory (IDT) further situates fintech adoption within broader social, spatial, and institutional systems. According to Rogers (2003), the diffusion of innovations depends on communication channels, peer effects, and system readiness. In developing economies, diffusion processes are often uneven due to infrastructure gaps, regulatory fragmentation, and limited institutional coordination, particularly in rural regions (Hassan & Umar, 2022; Jabeen & Yousaf 2024). These factors contribute to spatially differentiated adoption outcomes despite expanding technological availability. The system-level role of IDT in explaining spatial adoption disparities is outlined in Table 1.

In this study, Financial Intermediation Theory informs macro-institutional analysis, the Technology Acceptance Model guides interpretation of survey-based adoption behavior, and Innovation Diffusion Theory explains observed spatial and sectoral variation.

Table 1: Theoretical Framework and Analytical Mapping

Theory	Analytical Level	Key Variables / Evidence	Role in Analysis
Financial Intermediation Theory	Macro	Digital penetration, agri credit, agri output	Explains efficiency and allocation mechanisms
Technology Acceptance Model	Micro	Trust, perceived usefulness, ease of use	Explains adoption and sustained usage
Innovation Diffusion Theory	System	Rural diffusion, peer effects, infrastructure	Explains uneven spatial adoption

FinTech and Financial Inclusion: Beyond Access

The empirical literature broadly recognizes FinTech as a potentially powerful driver of financial inclusion, particularly in contexts where traditional banking systems are costly, inaccessible, or inefficient. Digital financial services reduce transaction costs, expand geographic reach, and enable customized financial products, thereby improving access for underserved populations. Beck et al. (2022) demonstrate that FinTech adoption is associated with higher account ownership and transaction activity in low-income economies, supporting the view that digital finance can widen formal financial participation.

Nevertheless, recent studies caution against equating FinTech access with meaningful financial inclusion. Inclusion increasingly encompasses sustained usage, service quality, and economic impact rather than mere account ownership. Empirical evidence suggests that FinTech outcomes are highly conditional on user trust, financial literacy, and regulatory credibility. Rahman and Lee (2024) find that perceived security and usability significantly influence adoption decisions in South Asian economies, while Akhter et al. (2023) show that digital financial services enhance resilience among marginalized groups only when supported by targeted literacy and trust-building measures.

The literature therefore converges on the conclusion that FinTech functions as an enabling mechanism rather than an automatic solution. Without supportive institutional frameworks and consumer protection mechanisms, digital finance risks reinforcing existing inequalities instead of alleviating them. This conditional perspective is particularly relevant for developing economies, where structural constraints often limit the depth and quality of FinTech adoption.

Digital Finance and Agricultural Development

The relationship between digital finance and agricultural productivity has gained increasing scholarly attention as agriculture remains a primary source of employment and income in developing economies. Traditional agricultural finance systems are characterized by delayed payments, limited credit access, and high transaction costs, which constrain farmers' investment decisions and risk management capacity. FinTech-based interventions aim to address these challenges by digitizing payments, enabling data-driven credit scoring, and facilitating access to insurance and subsidy programs.

Empirical evidence indicates that digital payment systems can improve liquidity cycles and reduce leakage in agricultural subsidy delivery. FAO (2023) documents that digitized transfers enhance transparency and timeliness, allowing farmers to make more informed input-purchasing decisions. Studies from South Asia further suggest that mobile financial services can support wage payments, micro-insurance, and savings mechanisms for agricultural workers, thereby stabilizing rural incomes.

However, the literature also emphasizes that agriculture-specific FinTech outcomes depend on sectoral integration. Malik and Hussain (2023) argue that generic digital finance expansion often remains consumption-oriented unless explicitly aligned with agricultural value chains. Similarly, Hassan et al. (2023) find that weak interoperability and limited product customization constrain the scalability of digital agriculture initiatives. These findings underscore that FinTech's effectiveness in agriculture is contingent on deliberate policy design rather than generalized digital banking growth

Comparative Regional Evidence and Institutional Design

Comparative studies consistently highlight institutional coherence as a decisive factor in determining FinTech effectiveness. Cross-country analyses show that economies with centralized governance structures, interoperable payment systems, and coordinated regulatory frameworks achieve stronger inclusion and productivity outcomes than fragmented systems. Nguyen and Tran (2024) demonstrate that institutional alignment significantly amplifies the developmental impact of digital finance across emerging Asian economies.

Public private collaboration also emerges as a critical enabler of FinTech diffusion. Studies emphasize that trust, affordability, and regulatory clarity facilitate adoption, particularly in rural contexts. Conversely, fragmented governance structures characterized by overlapping mandates and weak coordination often undermine policy effectiveness and slow diffusion, even when technological infrastructure is available.

This body of literature suggests that FinTech outcomes are shaped less by the sophistication of technology and more by the quality of institutional design. As such, comparative institutional analysis provides a valuable lens for understanding divergent digital finance trajectories across countries.

Research Gap and Conceptual Positioning

Despite extensive research on FinTech and financial inclusion, several critical gaps remain. First, there is limited empirical work directly linking FinTech diffusion to sector-specific productivity outcomes, particularly in agriculture. Second, comparative cross-country analyses that explicitly account for institutional and policy variation remain scarce. Third, existing studies rarely integrate macro-level indicators with micro-level behavioral evidence to explain adoption dynamics in rural economies.

To address these gaps, this study adopts an integrated theoretical framework drawing on Financial Intermediation Theory, the Technology Acceptance Model, and Innovation Diffusion Theory. Financial Intermediation Theory explains how digital finance reduces transaction costs and information asymmetries, enhancing allocative efficiency. The Technology Acceptance Model emphasizes perceived usefulness and ease of use as key drivers of adoption, while Innovation Diffusion Theory highlights the role of social learning, communication channels, and system readiness.

Together, these frameworks suggest that FinTech-driven inclusion and productivity gains depend on behavioral acceptance and institutional readiness rather than technological availability alone. This integrated approach provides a coherent analytical foundation for examining the FinTech–agriculture nexus in Pakistan and its regional peers.

In sum, the literature confirms FinTech's potential to enhance inclusion and productivity but also reveals that outcomes vary widely across institutional contexts. Digital finance delivers measurable benefits only when supported by coordinated policy design, infrastructure readiness, and user trust. By combining comparative regional analysis with primary survey evidence, this study advances understanding of how FinTech can transition from a financial innovation to a driver of agricultural transformation in developing economies.

4. Materials and Methods

Research Design and Approach

This study employs a mixed-methods research design that integrates quantitative and qualitative approaches to examine the relationship between FinTech innovation, digital banking penetration, and agricultural productivity in South and Southeast Asia. The focus is on Pakistan, with comparative analysis drawn from India, Bangladesh, and Malaysia. The design combines secondary cross-country data (2018–2024) with primary survey evidence collected from individual digital banking users in Pakistan.

The research design is exploratory–descriptive, consistent with the study's objective of identifying relationships and contextual mechanisms rather than establishing strict causality. The quantitative dimension captures macro-level financial and agricultural indicators, while the qualitative dimension assesses user perceptions, adoption behavior, and institutional barriers. This triangulation is associated with both validity and contextual interpretation, aligning with standard practices in development economics and financial inclusion research (Yin, 2023). Digital banking penetration is used as the primary quantitative indicator, while the FinTech Integration Rating serves as a qualitative, descriptive proxy capturing institutional coordination, interoperability, and regulatory readiness, with the index serving as a composite proxy. The FinTech Integration Rating is not used for econometric estimation but to support comparative institutional interpretation.

Data Sources and Variables

Secondary Data

Secondary data were compiled from international and national institutional sources for the period 2018–2024, including the World Bank, State Bank of Pakistan, Reserve Bank of India, Bangladesh Bank, Bank Negara Malaysia, FAO, and IMF. All monetary variables were converted to constant 2020 USD, and population-adjusted indicators were used to ensure cross-country comparability.

To contextualize Pakistan's FinTech position relative to regional peers, **Table 2** presents cross-country indicators on digital banking penetration, agricultural dependence, and FinTech integration.

Table 2: Cross-Country Digital Banking and Agricultural Indicators (2018–2024)

Country	Digital Banking Users (Million)	Digital Penetration (%)	Agriculture GDP Share (%)	FinTech Integration Rating (1–5)
Pakistan	24	15	19	2
India	450	40	17	5
Bangladesh	60	35	12	4
Malaysia	10	40	7	5

Note: The FinTech Integration Rating is a composite descriptive indicator based on regulatory readiness, interoperability, and institutional coordination.

Primary Data Collection

Primary data were collected through a structured questionnaire survey conducted between January and March 2024 across Bahawalpur, Multan, Rahim Yar Khan, Karachi, and Faisalabad. A total of 214 respondents participated, consisting of registered users of Easypaisa, JazzCash, and Raast.

Sample Characteristics and Usage Profile

The demographic composition of the survey sample is summarized in **Table 3**. The sample reflects Pakistan's rural demographic structure, with 60 percent rural respondents and a substantial representation of agricultural livelihoods.

Table 3: Demographic Characteristics of Survey Respondents (n = 214)

Variable	Category	Percentage (%)
Gender	Male / Female	60 / 40
Location	Rural / Urban	60 / 40
Age Group	18–25 / 26–40 / 41–60	28 / 45 / 27
Occupation	Farmer / Laborer / Small Business / Student	33 / 21 / 29 / 17
Education Level	Primary / Secondary / Higher	26 / 34 / 40

Table 4 presents the descriptive statistics summarizing respondents' usage patterns, platform preferences, perceived benefits, and barriers related to digital financial services. The results indicate a relatively high level of engagement, with 28% of respondents using digital financial services on a daily basis and 36% on a weekly basis, suggesting regular usage among the majority of participants. However, 36% of respondents reported monthly or rare usage, reflecting

continued heterogeneity in adoption intensity. In terms of platform preference, banking applications emerged as the most widely used platform (42%), followed by mobile wallet services such as Easypaisa and JazzCash (37%). The Raast payment system accounted for 21% of usage, indicating moderate but growing adoption.

Regarding the primary purpose of use, bill payments (40%) and fund transfers (38%) were the dominant activities, whereas payments for agricultural inputs (17%) remained comparatively limited. This highlights the transactional nature of current digital finance usage and suggests potential for expansion into agriculture-related financial services. Respondents identified speed (52%) as the most significant perceived benefit, followed by security (25%) and convenience (23%), underscoring efficiency as the primary driver of adoption. Conversely, internet connectivity (32%) and lack of awareness (28%) were reported as the major barriers, while trust (19%) and cost (12%) were relatively less constraining.

Table 4: Digital Banking Usage Patterns and Barriers

Indicator	Category / Response	Percentage (%)
Frequency of Use	Daily / Weekly / Monthly / Rarely	28 / 36 / 18 / 18
Platform Used	Bank App / Easypaisa–JazzCash / Raast	42 / 37 / 21
Primary Use	Bill Payments / Transfers / Agricultural Inputs	40 / 38 / 17
Perceived Benefits	Speed / Security / Convenience	52 / 25 / 23
Key Barriers	Internet / Awareness / Trust / Cost	32 / 28 / 19 / 12

These patterns indicate that while access to digital banking is widespread, productive usage in agriculture remains limited.

Given data constraints and cross-country heterogeneity, all indicators are interpreted as proxies rather than precise measures of fintech depth or productivity outcomes. Cross-country comparisons emphasize relative positioning and institutional patterns rather than exact numerical equivalence.

Analytical Framework

The analysis was conducted in three stages:

Stage 1: Descriptive Statistics

Descriptive summaries (mean, percentage share, frequency distributions) were used to analyze digital banking usage, trust levels, and perceived barriers. Cross-tabulations compared adoption rates by gender, education, and location.

Stage 2: Cross-Country Comparative Analysis

To contextualize Pakistan's progress, digital penetration, agricultural productivity, and FinTech maturity were compared across India, Bangladesh, and Malaysia. Ratio analysis and visual comparisons (bar and scatter charts) illustrated structural disparities in inclusion and innovation.

Stage 3: Correlation and Regression Analysis

A quantitative test of the hypothesized FinTech–agriculture relationship was performed using correlation and simple regression analysis. The base model is expressed as:

Given the limited number of countries included in the comparative analysis, regression estimates are interpreted as statistically supported associations that highlight the strength and direction of the FinTech–agriculture relationship within the observed sample. Statistical significance ($p < 0.05$), consistent with comparable cross-country exploration studies, these estimates are interpreted as indicative relationships rather than causal effects is reported to indicate robustness within the sample rather than to imply universal causality.

$$\boldsymbol{AGRI_OUTPUT_i = \alpha + \beta_1 DIGIPEN_i + \beta_2 AGRICREDIT_i + \epsilon_i} \qquad \textbf{eq \#1}$$

Where:

$\boldsymbol{AGRI_OUTPUT_i}$= Agricultural output per worker (USD),

$\boldsymbol{DIGIPEN_i}$= Digital banking penetration rate (% of adults),

$\boldsymbol{AGRICREDIT_i}$= Agricultural credit access (% of farmers with formal credit),

$\boldsymbol{\alpha}$= Constant, $\boldsymbol{\epsilon_i}$= Error term.

The model estimates the marginal effect of digital banking penetration on agricultural productivity, controlling formal credit access. Empirical findings show $\boldsymbol{\beta_1 > 0}$and statistically significant ($p < 0.05$), supporting the hypothesis that FinTech adoption is associated with sectoral productivity. The regression explains approximately 68% of variance in agricultural output ($R^2 = 0.68$), confirming a strong positive relationship.

Reliability and Validity

Instrument reliability was ensured through a pilot test involving fifteen respondents prior to the main survey. Cronbach's alpha for the multi-item Likert scales (covering trust, literacy, and usage) was 0.82, exceeding the 0.70 benchmark for internal consistency (Nunnally, 1978).

Construct validity was established by aligning survey dimensions with theoretical constructions from TAM and FIT (e.g., perceived ease of use, trust, accessibility). Triangulation between secondary and primary datasets further strengthened external validity, ensuring that findings reflected both individual-level and systemic realities.

Content validity was ensured through expert review by two faculty members of the Department of Economics, The Islamia University of Bahawalpur, who confirmed the instrument's relevance and coverage.

5. Results and Discussion

Results

Overview of Empirical Strategy

This section synthesizes evidence from macro-level cross-country indicators and micro-level survey data to assess how FinTech penetration translates into agricultural productivity outcomes. The analysis is structured around three dimensions: institutional context, empirical productivity linkages, and behavioral constraints, interpreted through Financial Intermediation Theory, the Technology Acceptance Model, and Innovation Diffusion Theory.

Cross-Country Patterns: Institutional Context Matters

Cross-country variation in FinTech outcomes reflects differences in institutional coordination rather than technology alone. Table 5 compares agricultural credit access and the extent to which digital channels support rural finance.

Table 5: Agricultural Credit Access and Digital Channels (2023)

Country	Farmers with Formal Credit (%)	Mobile / Online Credit Access (%)
Pakistan	33	6
India	68	24
Bangladesh	51	22
Malaysia	80	45

Pakistan's low level of digital agricultural credit access helps explain why FinTech expansion has not translated into comparable productivity gains.

FinTech Penetration and Agricultural Productivity

Table 6 presents the correlation matrix examining the relationships among digital FinTech penetration, agricultural output, and agricultural credit access. The results indicate a strong positive association between digital penetration and agricultural output ($r = 0.82$), suggesting that higher levels of FinTech usage are closely linked with improved agricultural productivity. This finding supports the argument that digital financial services can facilitate more efficient transactions, better access to inputs, and improved market participation in the agricultural sector.

The correlation between digital penetration and agricultural credit access ($r = 0.74$) is also positive and substantial, indicating that increased FinTech adoption is associated with improved access to agricultural credit. This relationship highlights the role of digital financial platforms in easing credit constraints faced by farmers through enhanced financial inclusion and reduced transaction costs.

Furthermore, agricultural credit access is strongly correlated with agricultural output (r = 0.79), implying that improved availability of credit contributes significantly to higher agricultural production. Overall, the correlation matrix confirms that FinTech penetration, credit access, and agricultural productivity are closely interconnected. However, while these correlations indicate strong associations, they do not imply causality and therefore motivate further econometric analysis.

Table 6: Correlation Matrix (2024)

Variable	Digital Penetration	Agricultural Output	Agricultural Credit
Digital Penetration	1.00	0.82	0.74
Agricultural Output	0.82	1.00	0.79
Agricultural Credit Access	0.74	0.79	1.00

Table 7 presents the regression results examining the relationship between FinTech penetration and agricultural productivity, while controlling agricultural credit access. The estimated coefficient for digital penetration is positive and statistically significant ($\beta = 0.72$, $p = 0.002$), indicating that higher levels of digital banking penetration are associated with increased agricultural output. This suggests that digital financial services play an important role in enhancing productivity by facilitating transactions, improving access to markets, and reducing financial frictions.

Similarly, agricultural credit access exhibits a positive and statistically significant effect on agricultural productivity ($\beta = 0.43$, $p = 0.007$), highlighting the importance of credit availability in supporting input purchases and productive investment in the agricultural sector. The constant term is also statistically significant, reflecting baseline productivity effects independent of the explanatory variables.

The model explains a substantial proportion of variation in agricultural output, with an R^2 value of 0.68, indicating strong explanatory power. Overall, the results confirm that digital banking penetration is significantly associated with higher agricultural output, conditional access to agricultural credit, reinforcing the complementary role of FinTech and credit availability in agricultural development.

Table 7: Regression Results – FinTech Penetration and Agricultural Productivity

Variable	Coefficient (β)	Std. Error	t-value	p-value
Constant	1.24	0.08	15.5	0.000
Digital Penetration	0.72	0.11	6.5	0.002
Agricultural Credit Access	0.43	0.09	4.7	0.007

$R^2 = 0.68$

Behavioral and Adoption Constraints in Pakistan

Despite the expansion of digital banking infrastructure in Pakistan, effective utilization within productive sectors remains limited due to behavioral, informational, and structural constraints. Evidence from the primary survey indicates that adoption is predominantly transactional rather than productive in nature. While a majority of respondents report regular use of digital banking platforms, engagement is concentrated in low-risk activities such as bill payments and peer-to-peer transfers, with comparatively limited use

for sector-specific purposes such as agricultural inputs, credit, or insurance.

Survey results reported in Tables 2 and 3 reveal pronounced rural–urban and usage-intensity disparities. Rural respondents, who constitute a substantial share of productive economic participants, exhibit lower engagement with advanced digital financial services. This pattern reflects not only infrastructure limitations but also gaps in awareness and familiarity with sector-relevant digital products. A significant proportion of respondents identified insufficient knowledge as a primary barrier, indicating that access alone does not translate into effective inclusion.

Trust-related concerns further constrain adoption. Respondents expressed apprehension regarding transaction security, dispute resolution mechanisms, and system reliability, particularly for larger or time-sensitive payments. Such concerns are more pronounced among users with volatile income streams, for whom perceived risk plays a critical role in financial decision making. Consistent with the Technology Acceptance Model, these trust deficits weaken perceived usefulness and discourage sustained engagement beyond basic transactions.

Gender disparities also emerge as an important constraint. Female respondents reported lower usage frequency and limited control over mobile devices, reinforcing existing inequalities in financial access. These patterns suggest that without targeted inclusion measures, digital banking expansion may inadvertently replicate preexisting socio-economic asymmetries Suri and Jack (2016).

Overall, the survey evidence highlights a disconnect between the availability of fintech services and their functional integration into productive economic activities. Behavioral barriers, particularly limited awareness, trust deficits, and gendered access constraints, continue to limit the depth of digital banking usage in Pakistan.

Interpreting the FinTech–Agriculture Nexus

The empirical findings suggest that digital banking penetration is associated with improved sectoral outcomes only when technological expansion is accompanied by institutional integration and sustained user adoption. Cross-country comparisons indicate that Pakistan's relatively shallow productive usage of digital finance reflects weak alignment between fintech platforms and sectoral policy frameworks rather than limited technological availability.

From a Financial Intermediation Theory perspective, fragmented institutional coordination constrains the efficiency gains typically associated with digital financial intermediation. Although platforms such as Raast and the Kissan Card have expanded digital access, their limited linkage with sectoral institutions, value chains, and service delivery mechanisms reduces incentives for users to transition from cash-based to digital transactions.

Comparative evidence highlights the role of institutional embedding in strengthening fintech outcomes. In India, digital payment platforms are integrated with subsidy disbursement systems, credit programs, and welfare transfers, creating repeated and low-risk interaction points for users. This institutional anchoring supports learning effects and reinforces trust, contributing to broader and more sustained adoption. Malaysia demonstrates a complementary model, where sector-specific digital finance is delivered through dedicated institutions such as Agrobank, facilitating targeted financial services aligned with sectoral needs.

Innovation Diffusion Theory helps explain why adoption patterns in Pakistan remain spatially and functionally uneven. Limited interoperability, weak coordination across agencies, and the absence of unified digital governance slow diffusion beyond urban and consumption-oriented use cases. Behavioral constraints identified in table 8 interact with these institutional weaknesses, further suppressing productive engagement.

Taken together, the findings underscore that fintech-driven transformation is not automatic. Digital banking is associated with improved outcomes only when embedded within coherent institutional frameworks and supported by user-centered implementation strategies. Pakistan's experience illustrates the risks of a fragmented approach, where technological expansion outpaces institutional readiness, limiting the potential developmental impact of fintech initiatives.

Table 8: Institutional Mediation of FinTech Outcomes

Country	FinTech Penetration	Institutional Coordination	Agricultural Productivity Outcome
Pakistan	Low–Moderate	Fragmented	Weak translation
India	High	Strong	High translation
Bangladesh	Moderate	Partial	Moderate translation
Malaysia	High	Strong	High translation

Comparative Policy Implications

Table 9 summarizes the key empirical findings of the study by highlighting the relationships between digital banking, institutional conditions, and agricultural productivity. The table shows a strong positive association between digital banking penetration and agricultural productivity, indicating that increased access to digital financial services is closely linked with improved agricultural performance. The results further demonstrate that institutional coherence significantly strengthens the developmental impact of FinTech, suggesting that coordinated regulatory and governance frameworks enhance effectiveness.

The table also reveals that, in Pakistan, FinTech adoption remains relatively shallow and is primarily oriented toward consumption-based activities rather than productive investment. Trust-related concerns, usability challenges, and limited digital connectivity emerge as major binding constraints, particularly in rural areas, restricting broader and more effective adoption. Cross-country comparisons reported in Table 9 indicate that countries with centralized FinTech governance structures outperform those with fragmented systems. Finally, the findings suggest that FinTech contributes to productivity gains only when it is embedded within agricultural value chains, rather than operating as a standalone financial access mechanism.

Table 9: Comparative Digital Finance and Agricultural Policy Models

Country	Core FinTech Model	Key Institutional Feature
India	UPI-based interoperability	Centralized digital governance
Bangladesh	bKash (PPP model)	Trust-based public–private partnership
Malaysia	Agrobank digital integration	Institutionalized agri-finance
Pakistan	Raast, Kissan Card	Fragmented implementation

6. Summary of Key Findings

The key findings of this study reveal a strong positive association between digital banking penetration and agricultural productivity, with a correlation coefficient of 0.82, indicating that expanded access to digital financial services is closely linked to improved agricultural outcomes. The results further show that institutional coherence plays a critical role in amplifying the developmental impact of FinTech, as countries with centralized and well-coordinated governance frameworks consistently outperform those characterized by fragmented regulatory systems. In the context of Pakistan, FinTech adoption remains relatively shallow and largely consumption-focused, limiting its contribution to productive investment in agriculture. Moreover, trust deficits, usability challenges, and inadequate digital connectivity emerge as binding constraints on rural adoption, restricting sustained and effective use of digital financial services. Importantly, the findings suggest that FinTech contributes to agricultural productivity only when it is embedded within agricultural value chains, rather than operating as a standalone financial access mechanism.

7. Conclusion

This study provides empirical evidence on the role of digital banking and FinTech in supporting agricultural productivity, with particular emphasis on institutional and structural conditions. The findings indicate a strong positive association between digital banking penetration and agricultural productivity, highlighting the potential of digital financial services to contribute to sectoral performance when effectively deployed. However, this relationship is not automatic and is significantly shaped by the broader institutional environment.

The results further demonstrate that institutional coherence plays a critical role in amplifying the developmental impact of FinTech. Countries with centralized and coordinated FinTech governance frameworks exhibit stronger performance outcomes compared to those characterized by fragmented regulatory systems. In the context of Pakistan, FinTech adoption remains relatively shallow and largely consumption-oriented, with limited integration into productive agricultural activities.

Moreover, trust deficits, usability challenges, and inadequate digital connectivity emerge as binding constraints on rural FinTech adoption. These barriers restrict sustained usage and limit the ability of digital financial services to support productivity-enhancing investments. The findings also suggest that FinTech contributes to agricultural productivity primarily when embedded within agricultural value chains, rather than through standalone financial access.

Overall, the study underscores that digital finance can serve as a catalyst for agricultural development only when supported by coherent institutions, reliable infrastructure, and sector-specific integration strategies.

8. Ethical Considerations

All participants were informed of the study's purpose and provided informed consent before participating. Data collection adhered to principles of confidentiality and voluntary participation. No personal identifiers were retained, and all responses were anonymized during analysis.

Ethical approval for this research was obtained from the Departmental Ethics Committee, The Islamia University of Bahawalpur (Approval No. IUB-ECON/2024/112). The study also complied with the SBP Data Protection Guidelines (2023) to ensure responsible handling of digital and financial information.

9. Limitations of the Study

The primary survey is not intended for statistical generalization but to contextualize macro-level patterns with user-level behavioral evidence. Despite the robustness of its mixed-methods approach, this study faces certain limitations:

1. **Temporal limitation:** Primary data were cross-sectional, constraining the ability to infer causality over time.
2. **Geographical scope:** While geographically diverse, the survey excluded remote northern and western districts due to connectivity constraints.
3. **Comparability of secondary data:** Variations in data definitions across institutions may introduce minor inconsistencies.
4. **Measurement constraint:** Self-reported behavioral indicators (e.g., trust, perceived risk) are subject to response bias.

Nonetheless, the combined use of institutional data, rigorous sampling, and theoretical alignment is associated with the study's credibility and provides a comprehensive lens for evaluating the FinTech–agriculture nexus in Pakistan and its regional peers.

10. References

Agrobank. (2023). *Annual report 2023: Advancing digital agricultural finance in Malaysia*. https://www.agrobank.com.my

Akhter, S., Rahman, M., & Sultana, R. (2023). Digital financial services and women's financial resilience in rural Bangladesh. *Journal of Development Economics and Policy*, *45*(2), 113–128.

Bangladesh Bank. (2023). *Mobile financial services (MFS) comparative summary statement: Annual report 2023*. https://www.bb.org.bd

Bank Negara Malaysia. (2023). *Financial stability review 2023: Advancing digital finance in Malaysia*. https://www.bnm.gov.my

Beck, T., Chen, T., & Song, F. (2022). FinTech and financial inclusion: Global patterns and policy implications. *Journal of Banking & Finance*, *141*, 106505. https://doi.org/10.1016/j.jbankfin.2022.106505

BRAC. (2023). *Digital financial inclusion and rural livelihoods: The bKash experience*. BRAC Research and Evaluation Division.

Chaiya, C., Sikandar, S., Pinthong, P., Saqib, S. E., & Ali, N. (2023). The impact of formal agricultural credit on farm productivity and its utilization in Khyber Pakhtunkhwa, Pakistan. *Sustainability*, *15*(2), 1217.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, *13*(3), 319–340. https://doi.org/10.2307/249008

FAO. (2022). *Pakistan agricultural sector analysis: Policy and productivity constraints.* Rome: Food and Agriculture Organization.

Food and Agriculture Organization of the United Nations. (2023). *Digital agriculture transformation in Asia and the Pacific: Status and policy recommendations*. FAO.

Hassan, A., & Umar, S. (2022). Innovation diffusion and digital finance adoption: Evidence from developing Asia. *Technological Forecasting and Social Change*, *182*, 121824. https://doi.org/10.1016/j.techfore.2022.121824

Hassan, M., Nawaz, M., & Shah, Z. (2023). Digital agriculture, FinTech innovation, and financial inclusion in Pakistan: Empirical insights. *Asian Journal of Economics and Finance*, *9*(3), 67–85.

Hussain, S., Ur Rehman, K., & Iqbal, I. (2025). Digital financial inclusion and sustainable agriculture: an empirical analysis from rural areas of Pakistan. *Journal of Agribusiness in Developing and Emerging Economies*, 1-17.

International Monetary Fund. (2023). *Financial inclusion and digitalization in emerging and developing economies*. IMF.

Jabeen, N., & Yousaf, M. (2024). Financial technology and inclusive growth: Assessing the rural–urban divide in Pakistan. *Sustainability*, *16*(5), 3124. https://doi.org/10.3390/su16053124

Jena, R. K. (2025). Factors influencing the adoption of fintech for the enhancement of financial inclusion in rural india using a mixed methods approach. *Journal of Risk and Financial Management*, *18*(3), 150.

Khan, A., & Ahmed, F. (2022). Mobile banking adoption and micro-entrepreneurial growth: Evidence from Pakistan. *International Journal of Finance & Economics*, *27*(4), 4465–4482. https://doi.org/10.1002/ijfe.2438

Kshetri, N. (2021). The role of artificial intelligence in promoting financial inclusion in developing countries. *Journal of Global Information Technology Management*, *24*(1), 1-6.

Levine, R. (1997). Financial development and economic growth: Views and agenda. *Journal of Economic Literature*, *35*(2), 688–726.

Malik, F. A., & Sikarwar, T. S. (Eds.). (2025). *The economics of financial inclusion*. Routledge.

Malik, R., & Hussain, S. (2023). Evaluating Pakistan's digital agriculture initiatives: Challenges and policy lessons. *Pakistan Development Review*, *62*(1), 59–78.

Ministry of Finance, Government of Pakistan. (2023). *Pakistan economic survey 2022–23*. https://www.finance.gov.pk

Nguyen, H. T., & Tran, Q. N. (2024). Institutional coherence and FinTech-driven inclusion: Evidence from ASEAN economies. *Journal of Asian Economics*, *86*, 102028. https://doi.org/10.1016/j.asieco.2024.102028

Nguyen, V. P., & Vo, D. H. (2023). Financial intermediation, digital innovation, and inclusive growth: Panel evidence from emerging Asia. *Emerging Markets Finance and Trade*, *59*(9), 2501–2518. https://doi.org/10.1080/1540496X.2023.2172041

Nunnally, J. C. (1978). *Psychometric theory* (2nd ed.). McGraw-Hill.

Osahon, O. B. (2025). Financial inclusion as a strategy for sustainable business financing in the emerging economies. *FULafia International Journal of Business and Allied Studies*, *3*(1), 49-69.

Perveen, F., Shang, J., Zada, M., Alam, Q., & Rauf, T. (2021). Identifying the determinants of access to agricultural credit in Southern Punjab of Pakistan. *GeoJournal*, *86*(6), 2767-2776.

Rahman, M., & Lee, S. (2024). Digital trust and sustained FinTech usage in South Asia: Moderating role of financial literacy. *Electronic Commerce Research*, *24*(3), 721–739. https://doi.org/10.1007/s10660-024-09635-2

Rahman, M., Ullah, F., & Karim, M. (2023). Determinants of FinTech adoption: Evidence from South Asian economies. *Technological Forecasting and Social Change*, *190*, 122375. https://doi.org/10.1016/j.techfore.2023.122375

Rao, A., Dagar, V., Sohag, K., Dagher, L., & Tanin, T. I. (2023). Good for the planet, good for the wallet: The ESG impact on financial performance in India. *Finance Research Letters*, *56*, 104093.

Reserve Bank of India. (2023). *Annual report 2023–24: Expanding digital payment ecosystems*. https://www.rbi.org.in

Rogers, E. M. (2003). *Diffusion of innovations* (5th ed.). Free Press.

Somuncu, K. (2025). The Relationship Between Financial Inclusion and Real Economic Growth: Examples from Turkey, Developing Countries, Developed Countries, and the World. *Yönetim Bilimleri Dergisi*, *23*(55), 310-335.

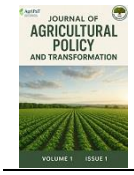
State Bank of Pakistan. (2023). *Annual financial stability review 2023*. Government of Pakistan https://www.sbp.org.pk

State Bank of Pakistan. (2023). *Data protection and consumer protection framework for digital financial services*. https://www.sbp.org.pk

Suri, T., & Jack, W. (2016). The long-run poverty and gender impacts of mobile money. *Science*, *354*(6317), 1288–1292. https://doi.org/10.1126/science.aah5309

World Bank. (2023). *Global FinTech report 2023: Digital finance for inclusive growth*. World Bank Group.

Yin, R. K. (2023). *Case study research and applications: Design and methods* (7th ed.). Sage Publications.



Journal of Agricultural Policy and Transformation (AgriPaT)

Journal homepage: http://www.ageconfrontiers.com/agripat

Institutional Governance and Smart Resource Management in Faisalabad's Industrial Sector

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ARTICLE INFO

Keywords:
Smart Governance
Institutional Reform
Resource Management
Technology Integration
Citizen Participation
Industrial Governance

Received: 21 November 2025

Received in revised form: 26 December 2025

Accepted: 27 December 2025

Available online: 06 January 2026

ABSTRACT

Smart cities signal a clear shift in how urban and industrial spaces are governed, managed, and maintained, with digital innovation and participatory approaches at the center of decision-making. This paper examines how institutional governance can enable the adoption of smart city principles in the industrial sector of Faisalabad. The study draws on a structured review of peer-reviewed literature indexed in Scopus, Web of Science, and Google Scholar published between 2020 and 2025, supplemented by relevant government and NGO reports. After applying defined inclusion and exclusion criteria, a thematic analysis was conducted to synthesize key insights.

The paper contributes to the literature by integrating Institutional Theory with Smart Governance Theory to explain how governance arrangements shape the effectiveness of digital technologies in industrial cities within developing economies. Findings highlight that technology-driven governance and active stakeholder engagement are critical for efficient resource management and sustainable industrial growth. Three coordination mechanisms emerge as central to improving governance outcomes: strong institutional coordination, digital transparency, and effective public-private partnerships.

Faisalabad's industrial base, particularly its textile and export-oriented sectors, shows strong potential for transformation through smart resource management, including IoT-based monitoring, data-driven energy management, and digital waste systems. However, the study also identifies persistent institutional barriers, such as bureaucratic rigidity, weak data-sharing mechanisms, and limited inter-agency collaboration. Addressing these challenges requires integrated smart governance frameworks that align technological advancement with inclusive and accountable decision-making. Overall, the study adds context-specific evidence to global debates on smart governance, with relevance for developing economies where digital readiness and governance reforms are still evolving.

1. Introduction

Agriculture The concept of fast urbanization and industrialization in the developing economies like Pakistan has posed urgent issues to institutional governance and sustainable management of resources. The last twenty years have witnessed the increasing housing, transportation, and industrial infrastructure demands in cities in the Global South, which resulted in elaborate governance pressures and environmental deterioration. Indicatively, in Pakistan, urbanization has been associated with the expansion in the use of energy in transportation and households, which leads to environmental degradation. In this regard, smart cities have become a revolutionized model, which incorporates the application of information and communication technology (ICT) in the management of the state to enhance the provision of services, transparency, and sustainability. Nevertheless, as the research underlines, the development of smart cities in the context of developing countries does not only demand the introduction of technology, but it also involves far-reaching institutional change (Maulana et al., 2025; Kaponda, 2025).

Smart cities are not, however, merely a matter of technological progress, but a matter of institutional change - of redesigning the administrative framework, policies, and citizen engagement, to allow smarter and more inclusive decision-making. This entails a redesign of the governance models, development of the interoperable data systems, and the establishment of

collaboration among the stakeholders. The empirical evidence indicates that institutional innovation, including the reform of legal frameworks, the reorganization of the public agencies, and the greater involvement of the stakeholders, plays a crucial role in strengthening smart-city governance and makes it more satisfactory to the stakeholders (Bokhari and Myeong, 2024; I-Gov et al., 2024).

Equally, studies point out that smart administration is advantageous with mission-driven methods and entrepreneurial ecosystems that is evident in the long-term experiments in Japan (Kitagawa, 2025).

Faisalabad as a Case Context

The city of Faisalabad is commonly referred to as the Manchester of Pakistan and it will provide a good example to test the intertwining of institutional governance and technology with the sustainability of industries. It is a significant contributor to the national economy of Pakistan, especially its textile industry; the Faisalabad Master Plan 2021-2041 indicates that textiles and other manufacturing industries are still the focus of the industrial sector (Faisalabad Development Authority, 2021).

In Faisalabad, the institutional government is also divided. Various agencies, such as the Faisalabad Development Authority (FDA), Water and Sanitation Agency (WASA) and industrial estate authorities, have overlapping mandates and few coordination frameworks. Such disintegration undermines the implementation of policies and limits the introduction of intelligent technologies in managing available resources sustainably. There is also evidence that the digital modernization of the public-service performance still is underdeveloped which represents more general restrictions in governance in urban Pakistan (Khalid et al., 2025).

Smart Cities and Institutional Governance

Institutional governance is a term used to refer to formal structures, rules, and processes whereby decision-making among the public and the privates takes place. In the context of smart-cities, governance is moved out of the traditional hierarchies and the so-called networked governance, in which government, industries and citizens work together in collaborative systems, digital and interoperable (Bokhari and Myeong, 2024). This change is essential since the success of a smart city does not exist solely in technology, but in the institutional innovation: the changes in the legal system, institutional structure, and mechanisms of participation are essential to capitalize on the digital transformation (Nadeem et al., 2025).

Institutional fragmentation is a significant challenge to smart city development in Pakistan. There are further reforms of decentralization and multilevel governance, which have not been consistent and frequently without significant coordination between government levels (Taj & Baker, 2018).

Technology and Resource Management

Digital technologies, including the Internet of Things (IoT), Geographic Information Systems (GIS), and artificial intelligence (AI), can provide significant opportunities to enhance the management of resources in industrial cities. Such devices can track the energy consumption, water utilization, and pollution in real-time, allowing making decisions more accurately and regulating the situation. Yet, those technologies cannot bring their maximum benefits without well-developed institutional frameworks (Hardi et al., 2025).

In Pakistan, the technology-driven governance is held back by bureaucracies, lack of capacity to share data, and poor interoperability. The study of AI and government-related administration shows that the introduction of AI may increase the efficiency of bureaucratic operations by automating them and offering better visibility (Ahmad, 2025). The interoperability is particularly relevant: the inability of the institutions to share the data results in the fragmentation of the governance and the lack of coherence in managing resources. The global experience demonstrates that cross-sectoral cooperation is an effective approach to enhancing smart-city governance and to better human-security results (Hardi et al., 2025).

Stakeholder and Citizen Involvement

Smart governance is all about citizen participation. Citizens are now able to report problems, provide data, and participate in the processes of planning, through their digital platforms, and make governments more transparent and responsive. A methodological review of smart-city applications determines the trend of popularizing mobile reporting devices and digital platforms of participation to enhance urban management throughout the world (Bastos et al., 2022).

The participation of citizens in Pakistan is however weak. In e-governance studies, the implementation of ICT tools in service delivery is observed to be limited in

terms of participatory activities by political, socio-cultural, and institutional environments (Atique, 2024).

Research Gap and Justification

Although most smart-city literature in the world has dealt with developed settings, including Singapore, Seoul, and Amsterdam, only a limited amount of empirical work on industrial cities in developing economies has been done. A systematic review of smart-city governance in developing nations also notes the general lack of research in the area focused on socio-institutional changes, like regulatory frameworks and citizen engagement (Tan & Taeihagh, 2020).

In Pakistan, smart governance is mostly being studied from the perspectives of infrastructure and e-governance tools, as opposed to more fundamentally embedded institutional architecture such as inter-agency coordination, capacity building and participatory governance. As an illustration, other studies on AI adoption in Pakistani bureaucracy focus on its efficiency benefit but mention their entrenched institutional bottlenecks that restrain the effectiveness of governance (Ahmad, Elahi, and Khan, 2025).

This gap is notable since the use of smart governance and its success is determined by institutional innovation (e.g., change in norms, structure, and processes) and technological innovation working together. The empirical studies elsewhere demonstrate that the relationships between e-governance and stakeholder satisfaction are moderated by institutional and technological innovations (Bokhari and Myeong, 2024; Myeong and Bokhari, 2023).

Research Objectives

The paper is dealing with three main objectives:

1. To determine the institutional governance mechanisms (i.e., the inter-agency coordination, formal rules, capacity building) that facilitate the smart city development and the sustainability of industrial activities in Faisalabad.
2. To examine the role of technology and data systems (e.g., online platforms, real-time monitoring) in enhanced management of industrial resources in the city.
3. To assess the stakeholder and citizen involvement (industry actors, local residents, and civil society) as a contributor to a higher level of legitimacy, transparency, and effectiveness of the governance processes.

These are the objectives that correspond to the overarching goal of evidence-based policymaking that entails the use of secondary data sources (policy documents, scholarly literature, industrial reports) in order to promote methodological rigor without the necessity of primary data collection (Siddiqui, Rehman, and Ansari, n.d.; Bukhari et al., 2025).

Significance of the Study

This study has a number of contributions. It emphasizes the industrial sector of Pakistan, specifically Faisalabad, which is still not well-represented in smart governance studies (Tan and Taeihagh, 2020). The study reduces the gap between governance reform and technology adoption by focusing on the governance structures and institutional capacity (Bokhari and Myeong, 2024). The results will guide the local administrators, industrial leaders, and governmental organizations in creating joint, evidence-based plans of sustainable resource utilization (Ahmad et al., 2025; Myeong and Bokhari, 2023). Faisalabad insights can also be transferred to other South Asian industrial cities, such as Dhaka and Surat, that have similar problems, such as fast industrialization, fragmentation of governance, and lack of citizen participation (Temoor bin Aslam, Salman, Irfan, and Jabeen, 2018). Altogether, the research advances a holistic framework of smart governance that combines technological advancement, participation, and institutional change to advance accountability, sustainability, and inclusiveness (Bukhari et al., 2025).

2. Literature Review

Smart Governance and Institutional Capacity

Smart governance refers to the application of information and communication technologies (ICT) to enhance service delivery, transparency and citizen interaction. It is not only the automation of the existing processes, but also empowerment of a data-driven decision-making culture based on participatory mechanisms. The review of the literature on smart cities in the developing world focuses especially on the idea that technology is not enough that can be successful in smart governance; institutional, legal, regulatory, and human-capital reforms are required (Xu, Zuo, and Zhao, 2020).

It all depends on the capacity of the ailing institutions. Institutional competence (for example, the flexibility of

bureaucracy and the ability to innovate) is necessary without which digital transformation may halt. Myeong and Bokhari (2023) showed that institutional innovation in the form of structural and process reforms enhances the impact of e-governance in satisfaction of stakeholders in smart cities. Bokhari and Myeong (2024) also emphasized that it is only when the institutional and technological innovations are combined that smart city governance enhances such results as crime reduction and citizen satisfaction.

The institutional issues play an important role in the developing cities such as Pakistan. The problems that significantly hinder the effective digital governance include weak local government capacity and lack of inter-departmental coordination (Siddiqui, Rehman, and Ansari, n.d.). Leadership will also be necessary and the change should not only have tools but also a buy-in by the leaders of the public sector to initiate the change and improve the capacity (Bokhari, Park, and Manzoor, 2025).

Lastly, institutional capacity in smart governance is based on citizen trust and participation. The willingness of behavior to use e-governance systems and their effectiveness greatly depend on digital literacy, trust in institutions, and willingness to use (Memon, Hakro, Ujjan, and Abbasi, 2025).

Resource Management Enabled by Technology

Smart governance is based on the real-time information gathering and analytics through the use of IoT, AI, and big data platforms, which will allow the accurate monitoring of resources (energy, water, and emissions). Although concepts of global literature can be applied, there are still few applied studies in industrial settings in developing countries (Yaseen, Nawaz, and Zhaira, 2024).

The transparency and accountability of the Pakistani public sector have been improved through digital transformation but infrastructural and institutional barriers restrict comprehensive implementation. As an illustration, e-Office and citizen portals can only be enhanced with insufficient infrastructure and training (Yaseen et al., 2024). Also, the aspect of data sharing between industrial participants and local organizations is hardly analyzed. Systematic reviews point out that the lack of legal frameworks and non-interoperable data systems has restricted the effect of technological innovation on governance (Bokhari and Myeong, 2024). Digital divide also impacts on resource-management technologies and people cannot have equal access to quality connectivity and IoT infrastructure to implement it. Other research in other developing cities demonstrates that digital inequality invalidates the inclusiveness of smart governance policy (Aditya, Ningrum, and Nurasa, 2023).

Citizen and Stakeholder Participation

The key feature of smart governance is citizen involvement. New models pay more attention to co-production, i.e., citizens, businesses, and NGOs actively engage in decision making (Bokhari & Myeong, 2024). Nonetheless, a meaningful engagement is hindered by a number of barriers. These are the digital divide, the inadequacy of the institutional mechanisms (formal policy of participation), and the lack of trust to the government (CPDI, 2021; Haider, Shuwen, and Hyder, 2014). Low digital literacy and limited outreach can be a reason to see a low level of uptake of e-participation platforms in Pakistan (CPDI, 2021). There are also socio-technical challenges: marginalized or less tech-savvy stakeholders (including the laborers or low-income residence) may not use the digital platforms, even in the cases when these are available, which restricts inclusivity (Raza, 2020).

The other essential consideration is trust. Recent studies demonstrate that technological innovations, including AI-based governance tools, can change the outcomes of governance using the mediator of stakeholder trust. The successful adoption hinges on whether the technology is present or not as also the perception and usage of the technology by the stakeholders (Bokhari, Park, and Manzoor, 2025; Fatima, Sayed, Sajid, and Ali, 2025).

Faisalabad as a Case Study Situation

The city of Faisalabad is the third largest city of Pakistan and a big hub of industries and textile. Although the specific numbers are not much, it has been traditionally known as a textile factory with large-scale production and dyeing plants located in industrial zones like M-3 (Islam Republic of Pakistan, JICA; iPortal). This industrial growth is of great environmental footprints. The Faisalabad Regional Development Plan (Environment Sector) discusses that industrial emissions and traffic are the major causes of air pollution (Urban Unit, Punjab). Textile and dyeing industries are the sources of wastewater that pollute water because most industrial units treat their water insufficiently (Islam Republic of Pakistan, JICA).

The Faisalabad institutional governance is on the brink of collapse. Although there are environmental regulations, there is a lack of uniformity in enforcement and most industrial establishments are not fully compliant (iPortal). Civil society and international organizations have undertaken capacity-building programs. As an example, the project of the WWF called Integrated Local Environmental Strategies (ILES) engages SMEs in the Faisalabad textile industry to minimize the use of water and energy (WWF Pakistan, 2023). Nevertheless, there are still few institutional incentives to share data, report on the environment, or other forms of digital governance characteristic of smaller industrial actors.

The case provides a picture of potential and challenges of smart governance within an industrial city: adoption of technologies and environmental change are necessary, but real changes would not be possible without institutional frameworks that would encourage partnership, open data flow, and regulatory responsibility. Through a case study of Faisalabad, it is possible to draw lessons about how other developing economies industrialized cities would deal with to ensure coordination of governance, technology and sustainability.

Table 1. Summary of Prior Literature and Linkage to Study Objectives

Theme	Key Findings from Literature	Identified Gap	Link to Objectives
Institutional Capacity	Governance effectiveness depends on institutional reform	Limited focus on industrial cities	Objective 1
Technology & Resources	IoT improves efficiency but lacks governance integration	Weak institutional embedding	Objective 2
Participation	Participation improves legitimacy	Few formal mechanisms in Pakistan	Objective 3

Table 1 above gives a classified overview of the previous literature by pointing out the prominent themes, chief results, the identified research gaps, along with their direct mapping to the objectives of the current research. From the above table, previous research stresses the significance of addressing the capacity of institutions, technology and resources, and the engagement of stakeholders in the context of governance and efficiency enhancement. Meanwhile, the identified research gaps include the lack of emphasis on industrial cities, the integration of technology in the framework of institutions, and the formal engagement opportunity in the context of participation in the Pakistani setting.

3. Materials and Methods

Research Design

The qualitative secondary research design is used in this study. It is designed in accordance to systematic review and synthesis of available literature, policy documents, and institutional reports. The method is appropriate in cases where the primary data collection can be challenging because of political, logistical, or institutional facts. Key sources include:

1. Articles in scholarly databases, like Google Scholar, Scopus, and Web of science (2020-2025).
2. Government and planning documents, e.g., Faisalabad Regional Development Plan (Urban Unit, Punjab).
3. Environmental and industrial stakeholders, e.g., WWF-ILES project on resource efficiency (WWF Pakistan, 2023).
4. International comparison of other developing industrial cities.

It can be developed as a multi-source approach which allows the creation of the integrated concept of governance, institutional capacity and sustainability of resources.

Theoretical Framework

Institutional Theory (focusing on the influence of formal structures, norms, and rules on organizational behavior and

governance outcomes) guides the study, and Smart Governance Theory (focusing on the role of ICT and participatory mechanisms in enhancing accountability, transparency, and service delivery) is one of the theories. Integrating these theories, the research is examining not only an analysis of the technological tools used in Faisalabad, but also the institutional preconditions that make such tools work in Faisalabad. According to institutional theory, organizations follow the rules of the institutions in order to attain legitimacy and stability (Lawrence and Shadnam, 2008). Smart governance, its part, is based on the combination of digital technologies and citizen engagement to create more responsive and inclusive governance (MDPI smart governance literature; participatory governance in e-participation contexts; see, e.g., research on e-participation in smart cities).

The following are the research objectives which will be aligned in this study.

Search Strategy and Screening Process

A systematic literature review was done to find out the relevant studies concerning the study objectives. To provide a wide range of high-quality and peer-reviewed literature, three large academic databases, namely, Scopus, Web of Science, and Google Scholar, were employed. January 2020 to June 2025 was the period of the search; this range of years encompassed the latest and topically relevant scholarly works.

The search method involved preset key word combinations and Boolean operators. The major search terms were: capacity building, women leadership, self-efficacy, women in higher education and leadership ambition in public sector universities. These keywords were chosen because they are relevant to the research variables and theoretical model.

The results were narrowed down using clear inclusion and exclusion criteria. The studies were considered eligible when they were peer-reviewed journal articles, published in English, and concentrated on women in higher education or institutions of the public sector and when they covered the issues of capacity building, leadership development, or self-efficacy. The exclusion criteria included conference papers, editorials, dissertations, non-English publications, and studies that have no empirical or theoretical relevance.

The screening was done in a PRISMA-style manner. First, the records picked in the databases were consolidated and duplicate entries were eliminated. Screening was done on titles and abstracts to determine the relevance, and full-text screening was carried on the shortlisted articles. Upon completion of the screening and eligibility test, a final list of studies was chosen to be included in the review. Such a systematic screening process guaranteed the methodological rigor, transparency as well as relevance of literature that was incorporated.

Data Collection and Sources

This study search strategy employed the use of search words, including; Faisalabad industrial governance, textile pollution Faisalabad, smart city Pakistan Punjab, and institutional capacity local government Pakistan. The inclusion criteria were that they had to be peer-reviewed articles published no older than 2025 and also pertinent government or NGO reports, such as the Urban Unit and WWF reports, and must be in English. The exclusion criteria removed non-empirical blogs or opinion pieces, as well as studies that were specializing in residential smart cities only. After these criteria were taken into consideration, the final data is a balanced portfolio of scholarly research, planning reports, and provider reports.

Data Analysis Procedure

The thematic analysis was used in the study according to the method given by Braun and Clarke (2006). It has started with familiarization where all the chosen sources were repeatedly read and annotated. This was then followed by coding with deductive codes used to three pre-specified categories including institutional governance, adoption of technology and inductive coding used to identify other emerging sub-themes that included inter-agency coordination, data interoperability, and digital literacy. During the theme development phase, similar codes were put in the general thematic categories; e.g., the IoT monitoring, energy efficiency, and wastewater sensors were categorized under the theme of technology-enabled resource management. Lastly, the synthesis step incorporated all the clusters of thematic themes into a consistent story clarifying how systems of governance, technological solutions, and practices of stakeholders interacted within the industrial environment of Faisalabad (Braun & Clarke, 2006).

Triangulation

Triangulation was used in order to increase validity and reliability of the findings by comparing evidence based on various sources and data types as suggested by Denzin (2017). Government reports were cross-verified with academic literature on smart governance and the industrial resource management to ensure that the policy realities are taken into consideration, and the practical knowledge of the technology implementation has been presented in the industrial white papers which supplemented the theoretical outlooks. Also, international comparative research offered

standards on the evaluation of the Faisalabad governance mechanisms. Triangulation minimized bias that may arise when using one type of data and enhanced the strength of the study to come up with strong evidence-based conclusions.

Ethical Considerations

The research has used strictly secondary sources and involves no human subjects, which is typical of the documentary and desk-based research (Bowen, 2009). All used materials were referenced in APA guidelines 7th edition, which ensured the academic integrity and compliance with the traditional rules of academic writing (American Psychological Association, 2020). Moreover, every step of the analysis procedure was well-recorded, in line with the principles of transparency and reproducibility that are traditionally suggested in the approach to the qualitative research (Saunders, Lewis, and Thornhill, 2023).

Strengths and Limitations

The paper shows a number of strengths such as combining various sources of data, which offer a comprehensive view, the methodology used in the study is clear and reproducible, and the study does not face the logistical, financial and ethical problem of collecting primary data. Nevertheless, it is also limited. Lack of primary data can cause the omission of subtle stakeholder perceptions and the use of secondary sources can bring about the risk of certain information being biased or out of date. Also, local politics and informal activities might not be well represented and restrict the contextual knowledge.

4. Results and Discussion

Results

According to the discussion of the secondary sources, the system of governance in Faisalabad shows a progressive move towards the idea of a smart city. Nevertheless, this shift is still limited by structural fragmentation, poor procedural coordination and poor stakeholder integration. The findings are presented in four thematic dimensions, including institutional alignment, technology integration, stakeholder participation, and cross-dimensional interactions.

Institutional Alignment

The results show that there is poor cooperation between the industrial agencies and the municipalities in Faisalabad. The inefficiency of e-governance initiatives, as well as the efficiency of governance in general, is curtailed by this institutional fragmentation (Bokhari & Myeong, 2024). Despite the significant potential of artificial intelligence (AI) and information and communication technology (ICT) projects to improve the governance processes, Pakistani institutions lack the capacity to implement the smart governance systems on a large scale due to bureaucratic inefficiency and lack of capacity to manage such projects (Ahmad, Elahi, and Khan, 2025).

Technology Integration

There is evidence indicating that there is an uneven uptake of the Internet of Things (IoT) technologies in Pakistani industries. There is also an enhancement in predictive maintenance and operational efficiency in industries where IoT solutions are applied (Waheed et al., 2023). Arduino-based platforms were the low-cost industrial IoT (IIoT) that allowed real-time monitoring in small and medium-sized enterprises in resource-constrained settings (Majid et al., 2022).

Stakeholder Participation

The findings reveal that industrial stakeholders, especially in the textile industry, are increasingly interested in adopting the IoT technologies and joining the governance efforts to increase productivity and efficiency, minimize energy use, and reduce the cost of operations (Farooq et al., 2023). Although there has been this interest, formal structures of participatory governance are still weak. According to the literature, not much evidence of structured platforms/digital co-governance systems/participatory policy frameworks is found that includes active involvement of industrial actors, municipal authorities, and civil society organizations (Tan & Taeihagh, 2020).

Cross-Dimensional Findings

The results reveal that there is a close relationship between institutional alignment, technology adoption, and stakeholder participation. The problem of institutional fragmentation limits the successful integration of technology because the absence of coordinated governance bodies means that industrial IoT data cannot be used in the larger municipal or environmental framework (Majid et al., 2022). Likewise, ineffective participatory systems constrain the political applicability of technological projects since surveillance results are rarely converted into a governance system because of the lack of organized feedback systems (Farooq et al., 2023). Because of this, Faisalabad is in a middle of the road, with technological pioneers in the city, but without full-scale governance changes or participatory engagement models (Myeong & Bokhari, 2023).

Discussion

The The results highlight the fact that technological innovation is not a sufficient factor towards attaining sustainable smart city governance. Rather, active institutional organizations and participatory governance systems are important facilitators of fruitful digital change in industrial urban areas like Faisalabad.

Institutional Governance as a Facilitating Support

These findings are in line with the current literature that institutional governance is a key element of successful smart cities. The low levels of inter-organizational coordination in Faisalabad are representative of the general problem in developing economies, whereby the lack of unified power and conflict in strategic alignment hamper the results of integrated governance (Tan and Taeihagh, 2020). Accountability could be improved by strengthening the institutional frameworks, including the presence of public-private partnerships, interagency coordination councils, and formal data-sharing committees (Myeong and Bokhari, 2023).

Technology Integration and Data-Based Governance

According to the previous research, interoperable platforms and centralized dashboards will be the key to transforming the factory-level data into actionable insights to be used by municipal decision-makers (Myeong & Bokhari, 2023). Predictive analytics and IIoT systems are examples of automated industrial plants that support the feasibility of such integration in Pakistan (Waheed et al., 2023).

Stakeholder Engagement and Participatory Governance

In line with the literature, the results highlight that the stakeholder participation improves the governance legitimacy, compliance, and joint responsibility (Myeong and Bokhari, 2023). Participatory governance in Faisalabad, however, is still under-institutionalized and rather informal. Smooth smart governance would also need formal mechanisms such as advisory boards, online platforms of participation and citizen-industry councils, which would systematically integrate stakeholder feedback into the policymaking processes (Tan & Taeihagh, 2020).

Policy and Practical implications

The discussion indicates that Faisalabad and other industrial cities should focus on integrated reforms in governance to promote smart city programs. Formal interagency committees need to be strengthened by means of industrial associations, municipalities and environmental regulators. At the same time, interoperable digital infrastructure will have to be invested in to unify factory-level IoT data with more comprehensive urban governance systems (Majid et al., 2022). Lastly, the most important steps toward the sustainability and inclusion of smart city development include the establishment of participatory mechanisms and the investment in capacity-building initiatives centered on the establishment of digital literacy, data governance, and collaborative decision-making (Waheed et al., 2023; Razzak et al., n.d.).

Theoretical Contribution

By combining Institutional Theory and Smart Governance Theory, this study demonstrates that digital technologies alone do not produce smart governance outcomes unless embedded within coordinated institutional structures. This integrated perspective extends smart governance literature beyond technological determinism, particularly in developing-country industrial contexts.

5. Conclusion and Policy Implications

In this research, it is shown that smart governance in Faisalabad is based on institutional capacity, technological infrastructure, and stakeholder involvement. Factories are embracing IoT and automation, without which the absence of institutional alignment and participatory processes restrains the conversion of these innovations into improvements in the overall governance of the systems.

Key Recommendations

The results of the current research indicate that institutional capacity, technological integration, and stakeholder involvement are the factors that affect the achievement of smart governance in Faisalabad. Despite the growing industrial players using IoT, automation, and digital surveillance systems in Faisalabad, the findings reveal that such technological innovations have not yet been translated into the improvement of the governance in general. The main factor that explains this deficit is the poor institutional correspondence and a lack of formal participatory governance frameworks.

Regarding the specified institutional disintegration among industrial associations, municipal governments, and other environmental regulators, the study suggests creating formalized coordination frameworks in Faisalabad. To be more precise, the institutionalization of inter-agency committees or smart governance coordination units is to be used in order to facilitate the process of joint decision-making, sharing data, and regulatory alignment. This recommendation specifically relates to the fact that the introduction of industrial innovations into the city-level

planning and control is not possible due to the isolated practices of governance.

The findings also indicate that the governance value of industrial IoT systems is limited by the interoperability. The solution to this problem would be to focus the municipal authorities Faisalabad development on the creation of compatible digital infrastructure and unified data standards that would enable the data available at factory level to stimulate city-wide monitoring, planning and control processes. In the absence of these platforms, the IIoT applications will be limited to isolated factories, thus playing a lesser role in environmental management and urban sustainability.

In accordance with the weak stakeholder participation findings, the research suggests institutionalization of the continuous mechanisms of participatory governance in line with the industrial situation of Faisalabad. They should introduce the digital feedback platforms, advisory boards, and citizen-industry councils, which would facilitate the structured interaction between industrial actors, municipal authorities, and the civil society. The mechanisms would contribute to turning the interest of the stakeholders into meaningful co-production, accountability, and policy responsiveness and, as shown, the institutional and technological innovation improves the satisfaction of stakeholders and the performance of the governance (Myeong and Bokhari, 2023; Bokhari and Myeong, 2024).

The findings also demonstrate the problem of capacity limitations in the state institutions and industrial management. In order to fill this gap, the targeted capacity-building programs ought to be applied in Faisalabad, with an emphasis on digital literacy, data governance, and participatory practices among the government officials, industrial managers, and workers. This would enhance institutional preparation and better utilization of digital governance tools.

Lastly, due to the bureaucratic inefficiencies observed in the government's governance system, the research endorses a progressive adoption of artificial intelligence into the decision-making of the government and with the help of adequate regulatory and ethical standards. Analytics based on AI have the potential to increase transparency and shorten time spent on procedures, as well as aid evidence-based policymaking in the municipal government structures of the city of Faisalabad (Ahmad, Elahi, and Khan, 2025). Such technological changes should be accompanied by better institutional requirements and enhanced local governmental structures to anchor the decision-making process based on data into daily municipal functions.

Future Research

However, future studies have the potential to further the results by employing empirical research, including interviews, focus groups, or workshops, to understand the attitudes of governmental officials, factory managers, workers, and community members concerning the adoption of technology and changes in governance. The comparative studies with other industrial South Asian cities like Surat or Dhaka can also indicate the best practices in the integration of technology, governance, and stakeholders' participation. Longitudinal studies would also contribute to evaluating the changes in digital governance reforms over time and its impact on environmental performance, compliance with regulation, and trust among stakeholders. Additionally, the ethical aspect of AI, data privacy, and accountability of algorithms would help to ensure the responsible utilization of digital technologies in the municipal governments. Altogether, these guidelines can help build a more solid theoretical and practical basis of developing smart governance in industrial cities.

6. References

Aditya, T., Ningrum, S., & Nurasa, H. (2023). *Community needs for the digital divide in smart city policy: A study from an Indonesian city.* Heliyon, 9(8), e18932. https://doi.org/10.1016/j.heliyon.2023.e18932

Ahmad, K., Elahi, M. M., & Khan, A. R. (2025). *Smart governance in Pakistan: (Re-)thinking bureaucratic efficiency through AI integration.* The Critical Review of Social Sciences Studies, 3(2), 1684–1700. https://doi.org/10.59075/zyh56149

Aisyah, S., Hidaya, Z., and et al. (2024). *Transforming smart city governance for quality of life and sustainable development in Semarang City, Indonesia.* IETA Journal of Sustainable Development and Planning.

American Psychological Association. (2020). *Publication manual of the American Psychological Association* (7th ed.).

Atique, M. (2024). *An analysis of e-governance in Pakistan from the lens of the public sector.* Heliyon.

Bastos, D., Fernández-Caballero, A., Pereira, A., & Rocha, N. P. (2022). *Smart city applications to promote citizen participation in city management and governance: A systematic review.* Informatics, 9(4), 89. https://doi.org/10.3390/informatics9040089

Bokhari, S. A. A., & Myeong, S. (2024). *How do institutional and technological innovations influence smart city governance? Focused on stakeholder satisfaction and crime rate.* Sustainability, 16(10), 4246. https://doi.org/10.3390/su16104246

Bokhari, S. A. A., Park, S. Y., & Manzoor, S. (2025). *Digital government transformation through artificial intelligence: The mediating role of stakeholder trust and participation.* Digital, 5(3), 43. https://doi.org/10.3390/digital5030043

Bowen, G. A. (2009). *Document analysis as a qualitative research method.* Qualitative Research Journal, 9(2), 27–40. https://doi.org/10.3316/QRJ0902027

Braun, V., & Clarke, V. (2006). *Using thematic analysis in psychology.* Qualitative Research in Psychology, 3(2), 77–101.

Bukhari, S., Kamran, S. M., Asif, M., Abro, M. M. Q., & Zaman, K. (2025). *Engineering smart governance systems and e-government services for urban sustainability: A systems-based approach to SDG-aligned urban efficiency.* Spectrum of Engineering Sciences, 3(4), 304–322.

Denzin, N. K. (2017). *The research act: A theoretical introduction to sociological methods.* McGraw-Hill.

Farooq, M. S., Abdullah, M., Riaz, S., Alvi, A., Rustam, F., López Flores, M. A., … Ashraf, I. (2023). *A survey on the role of industrial IoT in manufacturing for implementation of smart industry.* Sensors, 23(21), 8958. https://doi.org/10.3390/s23218958

Fatima, R. B., Sayed, S., Sajid, M. A., & Ali, S. (2025). *Assessing the impact of digital governance on citizen participation and public service delivery: A comparative study of developing and developed countries.* Review Journal of Social Psychology & Social Works, 3(1), 99–109. https://doi.org/10.71145/rjsp.v3i1.80

Haider, Z., Shuwen, C., & Hyder, S. (2014). *Citizens' participation in e-government services: Comparative study of Pakistan & Singapore.* IOSR-JECE, 9(6), 35–48.

Hardi, R., Nurmandi, A., Purwaningsih, T., & Manaf, H. (2025). *Smart city governance and interoperability: Enhancing human security in Yogyakarta and Makassar, Indonesia.* Frontiers in Political Science, 7. https://doi.org/10.3389/fpos.2025.1553177

Islamic Republic of Pakistan, JICA. (n.d.). *Project for water supply, sewerage and drainage master plan of Faisalabad.*

Kaponda, T. (2025). *From new public management to digital public administration: Examining the role of technology in shaping super smart societies.* IJRISS, 9(5), 3306–3320. https://doi.org/10.47772/IJRISS.2025.905000257

Khalid, A., & others. (2025). *Inadequate governance of urban ecosystems in Lahore.* Urban Science, 9(5), 162.

Kitagawa, F. (2025). *Smart cities as "mission-oriented" innovation and entrepreneurial ecosystems.* Cambridge Journal of Regions, Economy and Society. https://doi.org/10.1093/cjres/rsaf019

Lawrence, T. B., & Shadnam, M. (2008). *Institutional theory.* In W. Donsbach (Ed.), *The international encyclopedia of communication* (Vol. 5, pp. 2288–2293). Blackwell.

Lim, B., Yigitcanlar, T. (2022). *Participatory governance of smart cities: Insights from e-participation.* Journal / MDPI.

Majid, M. I., Malik, E., Aslam, T., Mahfooz, O., & Maqbool, F. (2022). *Design and implementation of low-cost data acquisition system for SMEs in Pakistan.* Proceedings of the Pakistan Academy of Sciences, 59(4), 13–23. https://doi.org/10.53560/PPASA(59-4)784

Maulana, R. Y., Marjamat, U., Subekti, D., & Wicaksono, A. (2025). *Catalyzing digital transformation through smart cities initiatives in Indonesian local government.* Smart Cities and Regional Development, 9(1), 35–46. https://doi.org/10.25019/59kh3t06

Memon, B., Hakro, D. N., Ujjan, I., & Abbasi, S. (2025). *A behaviorally-driven software architecture for e-government adoption in Pakistan.* VFAST Transactions on Software Engineering, 13(2).

Myeong, S., & Bokhari, S. A. A. (2023). *Building participative e-governance in smart cities: Moderating role of institutional and technological innovation.* Sustainability, 15(20), 15075. https://doi.org/10.3390/su152015075

Nadeem, M., Matsuyuki, M. (2025). *Institutional challenges and opportunities for encouraging transit-oriented development in Lahore.* Transportation Research Interdisciplinary Perspectives.

Raza, I. (2020). *Digital divide and e-governance in Pakistan: Factors affecting the citizen portal app.* (MPhil thesis, PIDE).

Razzak, A., Haneef, A., Ahmed, W., & Ayub, A. (n.d. 2023). *Pakistan aqua surveillance and control using IoT and LoRa protocol.* IJCRT.

Saunders, M., Lewis, P., & Thornhill, A. (2023). *Research methods for business students* (8th ed.).Pearson. https://www.researchgate.net/publication/240218229_Research_Methods_for_Business_Students

Siddiqui, A. A., Rehman, S. S. U., & Ansari, M. I. (2025). *The future of e-governance in Pakistan: Current status and future direction.* Journal of Political Stability Archive. https://doi.org/10.63468/jpsa.3.4.10

Tan, S. Y., & Taeihagh, A. (2020). *Smart city governance in developing countries: A systematic literature review.* MDPI https://doi.org/10.3390/su12030899

Temoor bin Aslam, Salman, Y., Irfan, S., & Jabeen, N. (2018). *Smart cities – A multidisciplinary perspectives model.* South Asian Studies, 33(2), 435–459.

Transforming digital government in Pakistan: Challenges & citizen participation. Centre for Peace & Development Initiatives (2021). https://mjmsear.com/wp-content/uploads/2021/08/Transforming-Digital-Government-in-Pakistan-August-2021-Final.pdf

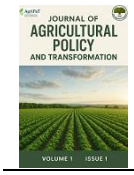
Waheed, F., Omar, M., Ibrahim, S. Z., Chugtai, R., & Aejaz, S. H. (2023). *Application of industrial IoT in developing a sustainable and automatic liquid filling plant.* Pakistan Journal of Scientific Research, 3(1), 130–140.

WWF Pakistan. (n.d. 2023). *Integrated Local Environmental Strategies (ILES) – Textile Sector.https://wwfasia.awsassets.panda.org/downloads/annual-report-2023_compressed--1-.pdf*

Xu, Y., Zuo, J., & Zhao, R. (2020). *Smart city governance in developing countries: A systematic literature review.* Sustainability, 12(3), 899. https://doi.org/10.3390/su12030899

Yaseen, A., Nawaz, A., & Zhaira, D. (2024). *The impact of digital transformation on public sector governance in Pakistan.* Journal of Neonatal Surgery. https://doi.org/10.63682/jns.v14i2S.9220

Zhang, H. (2022). *Digital transformation of smart industries and transformation of smart city governance models.* Proceedings of the International Conference on Internet Technology, Big Data & Security.



Journal of Agricultural Policy and Transformation (AgriPaT)

Journal homepage: http://www.ageconfrontiers.com/agripat

Assessing Socioeconomic Predictors of Nutritional Quality in Urban Households: A Case Study of Faisalabad, Punjab

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ARTICLE INFO

Keywords:
Socioeconomic Determinants
Healthy Diet
Dietary Diversity
Household Health
Income
Education
Regression Analysis
Nutritional Health
Faisalabad
Pakistan

Received: 21 November 2025

Received in revised form: 12 December 2025

Accepted: 31 December 2025

Available online: 06 January 2026

ABSTRACT

This study examines the socioeconomic determinants of healthy eating habits and their implications for household health outcomes in Faisalabad, Pakistan. The primary objective is to assess how household structure, employment status, education, income levels, and access to food shape dietary patterns across different socioeconomic groups. In Faisalabad, pronounced income disparities limit the ability of low-income households to access nutritious food, often resulting in poor dietary choices and a higher prevalence of diet-related diseases such as diabetes, obesity, and cardiovascular conditions.

Using primary data collected from households representing diverse socioeconomic backgrounds, the study explores dietary practices, levels of nutritional awareness, and food-related constraints faced by different demographic groups. Regression analysis reveals that socioeconomic factors play a significant role in shaping dietary diversity. In the first model, the Dietary Diversity Score (DDS) was used as the dependent variable ($R^2 = 0.208$; $p < 0.001$). Education, income, marital status, and home ownership were positively associated with DDS, while household size showed a negative relationship, indicating resource dilution in larger families. These findings suggest that households with greater economic stability and higher educational attainment tend to consume more diverse diets.

In the second model, Body Mass Index (BMI) served as the dependent variable ($R^2 = 0.029$; $p = 0.016$). DDS emerged as a positive but weak predictor of BMI, with a one-unit increase in dietary diversity associated with a 0.33-unit rise in BMI. Overall, the results indicate that while socioeconomic status strongly influences diet quality, dietary diversity alone has a limited effect on BMI, highlighting the importance of other factors such as lifestyle, physical activity, and genetic predispositions in determining household health outcomes.

1. Introduction

The foundation of human health and well-being is a nutritious diet, which affects productivity, growth, development, and survival at every stage of life. A healthy diet, according to the World Health Organization (WHO, 2023), guards against all types of malnutrition, including under nutrition, overweight, obesity, and food-related non-communicable diseases (NCDs) such type 2 diabetes, cardiovascular disease, and some types of cancer. Urbanization, globalized supply chains, and the rise in ultra-processed food availability have all contributed to changes in global food systems during the last three decades, which have had a substantial impact on dietary patterns and public health (GBD, 2024).

A number of Sustainable Development Goals (SDGs), such as those pertaining to hunger, health, and sustainable production, depend on eating a healthy diet (United Nations, 2024). The twin burden of malnutrition, where under nutrition and micronutrient deficiencies coexist with rising rates of obesity and NCDs, is a defining feature of nutrition issues in low- and middle-income countries (LMICs) like Pakistan (Global Nutrition Report, 2025). Therefore, identifying, assessing, and enhancing nutritious diets continues to be a top concern for economic development, public health, and policy.

A basic component of managing and preventing non-communicable diseases (NCDs), such as heart disease, obesity, type 2 diabetes, and some types of cancer, is diet. However, socioeconomic limitations frequently make it

difficult for underprivileged groups to obtain reasonably priced, nutrient-dense food, raising their risk of developing chronic illnesses (WHO, 2020). The key environment in which eating habits are established and sustained is the home. Children's academic performance, long-term health prospects, and physical and cognitive development can all be affected by poor household nutrition (Victora, 2008).

Not only can diet-related health problems impact individuals, but they also significantly overwhelm healthcare systems and lower worker productivity. In addition to lowering long-term healthcare expenses, preventive measures that target the underlying socioeconomic reasons of bad diets can enhance social well-being (Sassi, 2010). These changes have led to the extensive consumption of highly processed meals with a lot of sugar, salt, dangerous fats, and additives but poor in critical nutrients. Particularly in impoverished countries, the "nutrition transition," as this dietary change is known, has been linked to rising rates of obesity, metabolic syndrome, and other chronic health issues (Popkin, 2017).

Cultural, social, and financial factors greatly affect eating habits in Pakistan. Formerly grounded on home-cooked meals of whole grains, legumes, vegetables, and dairy, the traditional diet is gradually being substituted by processed meals high in salt, sugar, and bad fats. Particularly among urban populations and young people, fast food, soft drinks, and deep-fried snacks have become everyday consumption (Raza, 2019).

Dietary habits in Pakistan are shaped mostly by cultural norms and eating practices. Generally based on wheat or rice, meals usually feature meat, legumes, or vegetables. Particularly in traditional meals, however, overuse of salt, oil, ghee, and spices is usual. Across socioeconomic strata, deep-fried snacks like samosas and pakoras are popular; sugary desserts are sometimes ingested in great volumes during celebrations, family gatherings, and daily routines (Afzal, 2020). In order to preserve physical health and combat a variety of illnesses, a balanced diet is essential. The foods we eat sustain immune function, energy levels, and organ health while also providing the vital nutrients required for growth and development. Furthermore, dietary habits have a substantial correlation with preventing acute and chronic illnesses.

The direct effect of a good diet on physical well-being and the avoidance of chronic diseases is one of the fundamental reasons for its importance. Studies have consistently connected a low risk of heart disease, stroke, type 2 diabetes, and certain kinds of cancer to a diet high in fruits, vegetables, whole grains, lean meats, and healthy fats. The World Health Organization notes that poor diet is a significant risk factor for many of the top causes of death, including cardiovascular disease; therefore, a balanced diet is very important in avoiding these diseases.

Heart damage, stroke, and other cardiovascular illnesses are among the major causes of death globally. A good diet can help to significantly reduce the likelihood of these conditions by raising blood pressure, lowering cholesterol, and preserving healthy blood vessels. Diets strong in fruits, vegetables, and whole grains as well as a limited intake of heart-healthy fats like omega-3 fatty acids are associated with reduced probability of heart disease and stroke, according to the American Heart Association (2019). Two things for which these diets are well known are reducing inflammation, which is a necessary component in heart disease prevention, and promoting good weight reduction.

Eating a balanced diet rich in fiber fruits, vegetables, and whole grains helps to control blood sugar levels and delay insulin resistance. This, in combination with its role in preventing type 2 diabetes, makes eating a healthy diet absolutely critical. According to Hu (2001), a diet high in plant-based foods and low in processed foods could minimize the chances of type 2 diabetes by half. However, eating rich in refined carbohydrates and sugar-filled foods has been linked to a higher risk of developing the disease. Objectives of this research will be to explore the major socioeconomic factors that influence food consumption patterns, which include size of household, occupation, income, and level of education. This research will also seek to investigate food consumption patterns and their relationship to the general health outcomes of members of each household, which will be marked by how food consumption patterns affect overall general well-being. It will also seek to investigate general levels of various key health factors and food consumption patterns based on economic and level of education considerations.

2. Literature Review

Different theories have been put forth to explain these disparities. People with lower socioeconomic positions based on their work, income, or degree of education might not have the same material and psychological resources as those with higher socioeconomic positions. Healthy dietary behavior is recognized to be influenced by both financial resources, such as increased food budgets and access to health-promoting products and services, and psychosocial resources, such as cooking abilities, nutrition knowledge, and positive attitudes about healthy eating (Braveman, 2011).

(Ana, 2014) conducted a study based on 33 research reviews and 17 lower middle-income countries (LMICs) and showed significant variations in eating patterns according to socioeconomic status (SES) and urbanization. Most of the research, which used both cross-sectional and longitudinal approaches, originated in Brazil, China, and Iran. The results showed that higher intakes of calories, protein, fluids (including polyunsaturated saturating, and unsaturated fatty acids), cholesterol, iron, and vitamins A and C were linked to higher socioeconomic status and urban life. These groups also had lower fiber and carbohydrate intakes. Furthermore, higher socioeconomic status was associated with higher levels of diversity, higher quality diets, and higher fruit and vegetable consumption; although there were few studies in low-income countries, similar trends were noted, with one exception: fruit intake was lower in low-income countries' urban areas than in their rural ones.

According to the National Health and Nutrition Examination Survey (NHANES), individuals with more wealth ate nutrient-dense meals including whole grains, vegetables, and fruits more probably than those with poorer education and income levels, who were more likely to eat fast food, sugar-sugar-sweetened beverages, and processed snacks. Cultural standards, geographical location, and other environmental conditions all affect the way socioeconomic status influences eating patterns. Even though income was a strong predictor of food choices--according to a survey done in rural regions, for instance--local food policies and the presence of healthy food outlets greatly affected dietary patterns (Walker, 2010).

Black middle school students from low-income backgrounds were more probably to consume meat, fried meals, and empty-calorie food and less likely than their high-income White counterparts to eat grains, dairy items, fruits, and vegetables (Fahlman, 2010). Research on the motivational determinants of eating behavior, which have mostly focused on personal-level variables including taste preferences, nutrition knowledge, attitudes, and goals, have informed health education efforts to promote better eating habits including nutrition advice and counseling (Brug, 2005).

Conversely, people of little wealth are more liable to depend on inexpensive, high-energy, low-nutrient meals such processed snacks, sugary beverages, and fast food. Research never stops demonstrating that people with lower income have fewer access to healthy food choices. This is often due to financial restrictions as well as limited availability in food deserts (Walker, 2010). A National Health and Nutrition Examination Survey (NHANES) investigation found that lower-income and education groups consumed more sugary beverages, fast food, and processed meals while people with lower SES were more likely to consume nutrient-dense foods including fruits, vegetables, and whole.

The financial weight of food costs on lower-income families, especially in regions known as "food deserts" where supermarkets are scarce is worsened by other costs connected with food acquisition including transport to supermarkets. The increased financial pressure and limited access to nutrient-dense meals in these communities additionally reinforce their poor dietary selections (Walker, 2010).

Regardless of other socio demographic variables, the findings indicated that a low level of health literacy may negatively affect nutrition and physical activity, lending credence to the idea that health literacy is a key social determinant of health. Furthermore, the findings clearly revealed that people from lower socioeconomic classes have poorer health literacy. It is necessary to monitor the prevalence of socioeconomic factors, such as health literacy, among a nation's population in order to develop patient-centered healthcare policies and services, as well as to establish a society that is more knowledgeable about public health. In this respect, incorporating a health literacy evaluation instrument into risk factor or behavioral monitoring programs seems to be essential for developing more effective and comprehensive prevention and health promotion programs (Zanobini, 2021).

3. Materials and Methods

The study was carried out in Punjab province's major industrial and agricultural centre, Faisalabad, which is also Pakistan's third-largest city. Faisalabad is the perfect place to study the connection between socioeconomic determinants and nutritional outcomes because of its advantageous location and economic variety. The city offers a distinctive mix of job categories, economic groups, and access to food and healthcare resources because it includes both urban and peri-urban areas (Pakistan Bureau of Statistics, 2023).

Faisalabad's urban neighborhoods are distinguished by comparatively superior healthcare, education, and infrastructure. Peri-urban communities, on the other hand, frequently exhibit semi-rural characteristics, such as lower household incomes, greater rates of food insecurity, and restricted access to nutrition education, even though they are still a part of the urban environment (Imran, 2019). These differences offer a helpful foundation for investigating the ways in which dietary diversity and health are impacted by

differences in socioeconomic position. This study's target demographic consists of families in Faisalabad's urban and peri-urban areas. The study specifically targets households with an adult member (at least 18 years old) who can give accurate information about the socioeconomic status, food habits, and health of the household. Household heads and other adults who are knowledgeable with daily expenses, food buying habits, and family medical history are included in this.

It was a calculated decision to include a wide range of demographics in the household sample. Significant intra-urban disparities exist in Pakistan's urban terrain, spanning from affluent residential neighborhoods to impoverished villages. The study highlights the variation in food quality and nutrition access within a single city by enrolling respondents from both extremes. This diversity enhances the analysis and makes the results more broadly applicable. This study used a multi-stage stratified random sample procedure to guarantee representativeness and minimize sampling bias. Because of Faisalabad's socioeconomic diversity, stratified sampling was necessary to guarantee sufficient representation from both urban and peri-urban areas. Based on socio-spatial features and administrative boundaries, Faisalabad was first divided into these two major strata. Specific places were chosen at random from each stratum in the second stage. Households within the specified localities were picked at random for the third step.

A popular method in social science and public health research for examining heterogeneous groups is stratified random sampling (Kumar, 2019). It increases the validity of statistical inference by reducing the possibility of certain subgroups being over- or under-represented. Without stratification, for instance, a completely random sample may under sample from low-income or peri-urban areas and oversample from affluent metropolitan areas.

Cochran's formula for small populations was used to determine a sample size of 200 households:

$$n_0 = \frac{Z^2.p(1-P)}{e^2} \qquad \textbf{equ\#1}$$

Where:

- Z = 1.96 (for 95% confidence)
- p = the anticipated percentage of dietary diverse households (maximum variability assumed at 0.5).
- e = the error margin (0.05)

The final sample size was determined at 200 after accounting for the predicted response rate and the finite population. This is statistically sufficient for multiple regression analysis involving multiple independent variables.

The selected sample makes it possible to conduct in-depth analyses across subgroups and guarantees that the links and patterns found in the data are both contextually and statistically significant.

A structured questionnaire created especially to meet the goals of the study served as the main instrument for gathering data for this investigation. The questionnaire was broken up into five primary sections and included both closed-ended and open-ended questions:

1. Socioeconomic and demographic data, such as age, gender, income, education, and household size
2. Nutritional habits and food consumption frequency
3. Household members' health status, including height and weight for BMI calculations
4. Dietary costs and availability of nutritious dietary options
5. Ownership of assets and living circumstances

In this study, the main indicator of dietary quality and nutritional sufficiency is the Dietary Diversity Score (DDS). The number of distinct food groups consumed within a 24-hour recall period is used to compute the DDS. The following food groups are included in the DDS utilized in this study in accordance with the Food and Agriculture Organization's (FAO) guidelines:

1. Cereals
2. Roots and tubers
3. Vegetables
4. Fruits
5. Meat, poultry, and fish
6. Eggs
7. Legumes and nuts
8. Dairy products
9. Oils and fats
10. Sweets
11. Spices and condiments
12. Beverages (excluding water)

BMI serves as an objective indicator of the health consequences linked to food choices. It is computed using the following formula:

$$BMI = \frac{Weight\ (kg)}{Heitht\ (m)^2} \qquad \textbf{equ\#2}$$

Based on World Health Organization (WHO) standards, individuals are categorized as:

1. Underweight: BMI < 18.5
2. Normal weight: BMI 18.5–24.9
3. Overweight: BMI 25.0–29.9
4. Obese: BMI ≥ 30

The independent variables selected for this study are grounded in socioeconomic theory and previous empirical findings on nutrition and health determinants: Age, Marital Status, Household Size**,** Education Level, Income**,** Asset Ownership**,** House Ownership

Data Analysis Techniques

The study employed a two-pronged analytical approach: descriptive statistics to summarize sample characteristics and regression analysis to explore causal relationships between variables. These techniques were chosen for their ability to provide both an overview of the data and the statistical rigor needed to identify significant predictors of dietary diversity and health outcomes. Descriptive analysis was conducted using measures such as:

1. **Frequencies and percentages** for categorical variables (e.g., gender, marital status, house ownership)
2. **Means and standard deviations** for continuous variables (e.g., income, DDS, BMI, household size)

This provided a comprehensive overview of the demographic and socioeconomic composition of the 200 sampled households in Faisalabad. For example, household sizes ranged from 2 to 11 members, with a mean size of 6.1. Education levels varied widely, with respondents having 0 to 16 years of schooling. Such descriptive results help contextualize the population before conducting inferential analysis. To investigate the determinants of healthy dietary behavior and its impact on health, two multiple regression models were estimated:

Model 1: Determinants of Dietary Diversity Score (DDS)

$$\mathrm{HDS}_i = \beta_0 + \beta_1 lnincome_i + \beta_2(edu_i) + \beta_3 lnHS_i HS + \beta_4 \text{marital status} + \beta_5\ asset_i + \beta_6 lnage_i + e_i \ \textbf{e} \qquad \textbf{qu\#3}$$

This model uses DDS as the dependent variable, with socioeconomic and demographic indicators as explanatory variables. The model assesses how changes in income, education, and household structure affect dietary diversity

Model 2: Impact of Dietary Diversity on BMI

$$\mathrm{BMI}_i = \alpha_0 + \alpha_1 \mathrm{HDS}_i + \mu_i \qquad \textbf{equ\#4}$$

The impact of dietary quality (DDS) on household health as determined by BMI is investigated in this second model. A positive DDS coefficient would imply that healthier weight outcomes are linked to a more varied diet. The study's overarching goal, which is to connect socioeconomic determinants to both food patterns and real health outcomes, is addressed by this regression. This study conceptualizes dietary diversity as both an outcome of socioeconomic conditions and a proximate determinant of health outcomes. While this sequential framework is commonly used in nutrition and development research, it is acknowledged that the relationship between Dietary Diversity Score (DDS) and Body Mass Index (BMI) may be subject to endogeneity and reverse causality. In particular, individuals' body weight or health status may influence dietary choices and food diversity, just as dietary diversity may affect body weight. Due to the cross-sectional nature of the data and the absence of instrumental variables or longitudinal observations, causal inference cannot be established. Therefore, the estimated relationship between DDS and BMI in Model 2 should be interpreted as an association rather than a causal effect.

4. Results and Discussion

Descriptive statistics provide the foundational understanding of the variables used in regression models and nutritional assessments. Table 1 summarizes the central tendencies and dispersions of the key study variables. Below is a detailed analysis of each:

Table 1: Descriptive Statistics

Variable	Mean	Std Dev	Min	Median	Max
DDS (Dietary Diversity Score)	7.64	2.3	2	8	12
BMI (Body Mass Index)	23.32	4.41	13.93	22.8	37.1
Age	28.31	7.6	19	26.5	61
Gender (1 = Male, 2 = Female)	1.48	0.5	1	1	2
Marital Status	1.48	0.54	1	1	4
Years of Schooling	15.37	1.51	12	16	18
Employment Status (1–4)	1.8	0.9	1	1	4
Income *(PKR)*	71265	39850	10,000	60,500	250,000
Household Size	6.03	2.44	2	5	17
Dependents (children/elderly)	2.49	1.53	1	2	8
Meals per Day	2.76	0.92	1	3	10
Water Intake (glasses/day)	8.24	2.75	2	8	20

The dataset consists of responses from 200 individuals**,** capturing various demographic, socioeconomic, and health-related variables. Here's a breakdown of the key findings:

Dietary Diversity Score (DDS): The average DDS was **7.64**, with a minimum of **2** and a maximum of **12**, indicating a wide range in dietary diversity among respondents. A higher DDS suggests greater consumption of a variety of food groups, reflecting better dietary quality.

Body Mass Index (BMI): The average BMI was **23.32**, with a standard deviation of **4.41**, ranging from **13.93** (underweight) to **37.10** (obese). Most respondents fell within the normal weight range, but there is significant variation, indicating the presence of both underweight and overweight individuals in the sample. The average age of respondents was 28.31 years (SD = 7.6), ranging from 19 to 61 years. The relatively young sample suggests a population group in the economically active phase of life. Younger adults tend to have different dietary preferences compared to older individuals, including higher consumption of fast food, sweetened beverages, and processed items (Afshin, 2019). However, the regression model showed that older age correlates positively with healthier diets, likely due to increased awareness and concern for long-term health.

Gender: The average gender value was 1.48**,** indicating a nearly equal distribution of males and females (where 1 = male and 2 = female). With a mean of 1.48 and a range from 1 to 4, most respondents were single or married. As discussed in section 4.2, marriage is associated with more stable household routines and collaborative food choices. Shared responsibilities in meal preparation and financial management may enhance food diversity and frequency. Respondents had a high average of 15.37 years of schooling, with a minimum of 12 and a maximum of 18 years. This reflects a generally well-educated sample, which is consistent with urban sampling in a city like Faisalabad. Education is strongly correlated with better nutritional choices, as educated individuals are more likely to interpret food labels, follow dietary guidelines, and avoid harmful eating habits (Muthini, 2020).

Employment Status: With an average of 1.80 and a range of 1 to 4**,** the employment data indicates a mix of full-time, part-time, and possibly unemployed individuals or students. The distribution leans slightly toward full-time employment. The average monthly household income was PKR 71,265, with wide variability (SD ≈ 39,850), ranging from PKR 10,000 to PKR 250,000. This dispersion reflects the socioeconomic diversity of the sample. The strong positive association between income and DDS, as shown in regression analysis, aligns with numerous studies indicating that higher-income households can afford a wider array of foods, including more costly items like dairy, fruits, and meat (Maharjan, 2019). The mean household size was 6.03, with a maximum of 17. The average number of dependents (children/elderly) was 2.49. Larger families with more dependents typically face higher food burdens, leading to prioritization of quantity over quality. This resource dilution may explain the negative correlation between household size and DDS.

Number of Dependents: Respondents reported an average of 2.49 dependents (children or elderly), with some having as many as 8 dependents**.** More dependents can influence household food security and nutritional planning. Respondents reported consuming 2.76 meals per day on average, with some households indicating up to 10 meals. This figure may reflect snacking behavior or multiple small meal portions rather than full meals. Households eating fewer than three meals per day may be more susceptible to under nutrition, while those with frequent meals must also

ensure nutritional balance. Water consumption averaged 8.24 glasses per day, with responses ranging from 2 to 20. Adequate hydration is essential for digestion, nutrient absorption, and overall metabolic function. While water intake is not directly included in DDS or BMI calculations, it serves as an important behavioral health indicator. To determine which socioeconomic and demographic factors significantly predict Dietary Diversity Score (DDS), a multiple regression model was applied using DDS as the dependent variable and six explanatory variables: education, log-transformed income, log-transformed household size, marital status, house ownership, and log-transformed age.

Table 2: Test Statistics Results

Predictor	Coefficient	T statistics	p-value	Significance
Constant	-12.134	-3.264	0.001	Significant at 5%
Education	0.223	2.132	0.034	Significant at 5%
Log Income	2.772	4.063	0.00	Significant at 5%
Log Household Size	-1.993	-2.177	0.031	Significant at 5%
Marital Status	0.363	-2.419	0.016	significant at 5%
House ownership	0.542	2.490	0.014	significant at 5%
Log age	3.624	1.914	0.057	significant at 5%

R-squared: 0.608 **Adjusted R-squared:** 0.580 F-statistic: 7.225 (p = 0.0000)

The R-squared value indicates that about 61% of the variation in dietary diversity is explained by the included variables. While moderate, this is acceptable in behavioral studies where multiple unobserved factors influence outcomes (Gujarati, 2009). Table 2 presents the results of the test statistics coefficient for education was 0.223 ($p = 0.034$), indicating that for every additional year of schooling, the DDS increases by approximately 0.22 units. This positive and statistically significant relationship confirms that education plays a fundamental role in shaping dietary behavior. Household income exhibits a positive and statistically significant association with dietary diversity. The estimated coefficient on log-transformed income is 2.772 ($p < 0.01$), indicating that income is an important socioeconomic determinant of food choice in urban Faisalabad. Given the logarithmic specification of income, the coefficient should be interpreted as a semi-elasticity. Specifically, a 1 percent increase in household income is associated with an approximate 0.028-unit increase in the Dietary Diversity Score, holding other factors constant. Although the marginal effect appears modest, its statistical significance highlights the role of economic capacity in enabling households to access a broader range of food groups. Higher-income households are better positioned to afford relatively expensive and perishable foods such as fruits, vegetables, dairy products, and animal-source proteins, which are essential components of a diverse and nutritionally adequate diet. This finding is consistent with prior empirical evidence from urban settings in developing countries, which shows that income growth improves diet quality primarily through enhanced food variety rather than increased caloric intake alone. The result underscores the importance of income-enhancing and social protection policies in improving dietary quality among urban households. DDS dramatically declines with increasing home size, according to the coefficient for household size, which was -1.993 ($p = 0.031$). The principle of resource dilution, which states that as few food resources are shared by more people, the diversity of food available per capita is decreased, is reflected in this inverse relationship.

DDS was positively correlated with marital status, with a value of 0.363 ($p = 0.016$). The nutritional diversity of married people was somewhat higher than that of single people. This might be because marriage frequently brings with it a more regimented lifestyle, joint meal planning responsibilities, and a combined income. Family health and balanced meals may receive more attention in married households, especially those with kids. Married couples may also have more consistent cooking practices, which encourages the inclusion of a variety of foods. A strong

correlation between improved dietary diversification and home ownership was found, with a value of 0.542 (p = 0.014). Having a home is frequently a sign of long-term financial security and reduced monthly costs, which can free up funds for buying a wider range of foods. With a marginal p-value of 0.057 and a coefficient of 3.624, the age variable appeared to have a positive but marginally significant link with DDS. Due to their higher concern for their health, collected knowledge, and cooking experience, older respondents were more likely to report having varied diets.

BMI as Dependent Variable

A straightforward linear regression was carried out using BMI as the dependent variable and DDS as the only predictor in order to investigate the connection between dietary behavior and health consequences in more detail.

Table 3: Impact of Dietary Diversity Score (DDS) on the Outcome Variable

Predictor	Coefficient	T statistics	p-value	Significance
Constant	20.818	19.412	0.000	Significant at 5%
DDS	0.328	2.436	0.016	Significant at 5%

R-squared: .029 **Adjusted R-squared:** .024 **F-statistic:** 5.936 (p-value < 0.016).

Table 3 presents the results of the regression analysis, indicating that the Dietary Diversity Score (DDS) has a statistically significant effect at the 5% level. It is clear from this beneficial link that dietary diversity has an impact on physical health outcomes, especially body weight. A wider variety of foods consumed by households increases the likelihood that they will achieve their nutritional and caloric needs, leading to more ideal BMI levels. A greater DDS does not, however, automatically translate into a healthy BMI if the variety contains items that are high in energy but low in nutrients. For example, diets high in processed meals, sugar-sweetened beverages, and fried snacks may raise DDS but also result in overweight and obesity.

Mekonnen (2021) highlights that in order to determine DDS's actual health impact, it should be read in conjunction with food quality indices. In a similar vein, Sibhatu (2015) discovered that in underdeveloped nations, higher DDS is closely associated with better hemoglobin levels, better child growth outcomes, and fewer instances of stunting and underweight. The study's findings support the claim that DDS is a helpful, albeit imperfect, stand-in for dietary sufficiency and overall health in adult populations.

Limitation of the study:

Despite its contributions, this study has several limitations that should be acknowledged when interpreting the findings. First, the analysis is based on cross-sectional data, which restricts the ability to establish causal relationships between socioeconomic factors, dietary diversity, and health outcomes. In particular, the use of the Dietary Diversity Score (DDS) as both an outcome variable and an explanatory variable for BMI raises the possibility of endogeneity and reverse causality, as individuals' health status may also influence dietary choices. Second, BMI was used as the sole indicator of health, which, although widely applied in nutrition research, is a relatively crude measure that does not capture micronutrient deficiencies, body composition, physical activity levels, or other dimensions of nutritional health. Third, while the sample size is statistically adequate, the sample is skewed toward relatively well-educated respondents, which may limit the generalizability of the results to less-educated and lower-income urban households in Pakistan. Finally, unobserved factors such as food prices, dietary quality within food groups, lifestyle behaviors, and genetic predispositions were not captured in the data and may also influence both dietary diversity and health outcomes. Future research using longitudinal data, additional health indicators, and more representative samples would help to address these limitations and provide stronger causal insights.

5. Conclusion

According to the study's findings, socioeconomic factors significantly influence the food habits and health outcomes of urban households in Faisalabad. The results support the theories that dietary diversity and health indicators are positively impacted by household stability, money, and education. On the other hand, a larger household tends to dilute food supplies, which results in a lower-quality diet. Education directly increases food choice, cooking skills, and nutrition awareness, all of which contribute to higher-quality diets. Families may buy a range of nutrient-dense foods thanks to income, which is a powerful enabler of dietary diversity. Dietary diversity was negatively correlated with household size, which may indicate food insecurity and resource limitations. Home ownership and marital status were positively associated with better eating habits, underscoring the importance of stability in encouraging better food choices. Better diets were positively connected with age, most likely as a result of growing health consciousness and experience. Better diets translate into

better physical health, as evidenced by the statistically significant positive effect of the Dietary Diversity Score (DDS) on BMI.

Recommendations

The study's conclusions lead to the following practical suggestions for development planners, public health professionals, and legislators:

- Integrate nutrition education into school curriculums and adult literacy programs. Education on balanced diets, food groups, and health effects should be tailored to different literacy levels and community contexts.
- Introduce or scale up social protection schemes like food subsidies, income support, and employment guarantees, particularly targeting low-income families. Financial empowerment directly increases a household's ability to afford and choose a diverse, healthy diet.
- Promote kitchen gardening programs in urban and peri-urban areas, especially for low-income homeowners. This can improve access to fresh vegetables and reduce dependency on market prices.
- Design nutrition programs targeting newly married couples and young families to instill lifelong dietary habits. Culturally sensitive counseling sessions during pre-marital or post-marital workshops can be effective.
- DDS can serve as a practical and quick screening tool in primary healthcare centers to assess household food quality. This allows early identification of at-risk populations for targeted nutrition interventions.

6. References

Afshin, A. (2019). Global patterns of diet quality and health outcomes: A systematic review. *The Lancet Global Health, 7*(5), 432–445.

Afzal, M. (2020). Socioeconomic determinants of household dietary diversity in South Asia. *Journal of Nutrition and Health Sciences, 8*(2), 55–64.

American Heart Association. (2019). *Healthy eating recommendations for cardiovascular disease prevention*. https://www.heart.org

Ana, V. (2014). Nutrition interventions in low- and middle-income countries: A meta-analysis of 33 systematic reviews. *Public Health Nutrition, 17*(11), 2475–2489.

Braveman, P. (2011). Social determinants of health: The role of equity and structural disparities. *Annual Review of Public Health, 32*, 381–398.

Brug, J. (2005). Determinants of healthy eating: Motivation, opportunity, and abilities. *Appetite, 45*(1), 5–9.

Fahlman, M. (2010). Dietary behaviors among urban Black adolescents: Barriers to healthy eating. *Journal of School Health, 80*(5), 235–242.

GBD 2024. (2024). *Global Burden of Disease Study 2024 results*. Institute for Health Metrics and Evaluation. https://www.healthdata.org

Global Nutrition Report. (2025). *Global nutrition report 2025: Progress toward ending malnutrition*. Development Initiatives.

Hu, F. B. (2001). Diet, lifestyle, and the risk of type 2 diabetes: A review. *The New England Journal of Medicine, 345*(5), 790–797.

Imran, M. (2019). Determinants of food insecurity in households of developing countries. *Asian Journal of Agriculture and Development, 16*(3), 99–111.

Maharjan, K. (2019). Socioeconomic factors influencing dietary practices in South Asia. *International Journal of Social Economics, 46*(7), 875–890.

Mekonnen, T. (2021). Household dietary diversity and nutritional outcomes in urban Ethiopia. *BMC Public Health, 21*(1), 1104.

Muthini, D. (2020). Income inequality and dietary diversity among rural households in Kenya. *Food Policy, 92*, 101–112.

Pakistan Bureau of Statistics. (2023). *Pakistan Social and Living Standards Measurement Survey 2023*. Government of Pakistan.

Popkin, B. M. (2017). Relationship between global nutrition transition and chronic disease. *Obesity Reviews, 18*(S1), 7–13.

Raza, A. (2019). Socioeconomic drivers of unhealthy dietary patterns in Pakistan. *Pakistan Journal of Nutrition, 18*(4), 350–359.

Ruel, M. (2013). Nutrition-sensitive interventions and programs: A systematic review. *The Lancet, 382*(9891), 536–551.

Sassi, F. (2010). *Obesity and the economics of prevention: Fit not fat*. OECD Publishing.

Sibhatu, K. (2015). Farm production diversity and dietary diversity in developing countries. *Food Policy, 50*, 1–20.

Sinha, M. (2017). ICT exports, innovation, and GDP growth among OECD countries. *Technological Forecasting and Social Change, 122*, 15–25.

United Nations. (2024). *Sustainable Development Goals report 2024*. United Nations Publications.

Victora, C. (2008). Maternal and child undernutrition: Consequences for adult health and human capital. *The Lancet, 371*(9609), 340–357.

Walker, R. (2010). Food deserts, access inequalities, and dietary patterns: An urban analysis. *Health & Place, 16*(5), 1020–1025.

World Health Organization. (2020). *Diet, nutrition, and the prevention of chronic diseases*. Author.

World Health Organization. (2023). *Healthy diet*. https://www.who.int/news-room/fact-sheets/detail/healthy-diet

Zanobini, P. (2021). Health literacy, socioeconomic status, and dietary behavior: A cross-country comparison. *International Journal of Public Health, 66*, 160–169.